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AFATL-TR-71-157

DESIGN, DEVELOPMENT, AND FABRICATION OF THE FMU-63/B BOMB FUZE

HONEYWELL INC.

TECHNICAL REPORT AFATL-TR-71-157

DECEMBER 1971

(see form 1473)

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AIR FORCE ARMAMENT LABORATORY

AIR FORCE SYSTEMS COMMAND • UNITED STATES AIR FORCE

EGLIN AIR FORCE BASE, FLORIDA

Design, Development, And Fabrication

Of The

FMU-63/B Bomb Fuze

R.W. Shirley

FOREWORD

This report presents the results of work performed under Contract F08635-67-C-0051 with the Air Force Armament Laboratory, Eglin Air Force Base, Florida, by the Ordnance Division of Honeywell Inc., Hopkins, Minnesota, during the period 27 January 1967 to 31 December 1971. Captains Dallva C. Lemons, Edward J. LaGraize, and Stanley G. Hull and Mr. James E. Wetzel were program monitors for the Armament Laboratory.

The issuance of this contract followed exploratory work performed under Contract AF08(635)-3745, Modification 4. The details of this exploratory work are summarized in Technical Report AFATL-TR-67-80, Design, Development, and Fabrication of FMU-35/B Bomb Fuze, dated July 1967.

This technical report has been reviewed and is approved.

Norman S. Drake

NORMAN S. DRAKE, Colonel, USAF
Chief, Bombs and Fuzes Division

ABSTRACT

The work described in this report was performed in compliance with Contract F08635-67-C-0051 and subsequent Modifications P001 through P00019. All phases of a complete development program were carried out with a goal of developing a safe and reliable long delay fuze that is compatible with available subsonic and supersonic delivery systems. The final result of this development program was a long delay (1.0 hour to 199 hour) bomb fuze compatible with retarded or non-retarded bomb systems in either nose or tail fuze well installations. Air Force test and evaluation of the final FMU-63/B fuzes revealed a functional reliability far below the desired value. The FMU-63/B fuze was not approved for pilot production and this development program was terminated. Final test results will be reported in a separate Armament Development and Test Center technical report.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations, Symbols and Acronyms

AAFE - Arm and Fire Enable
AD - Anti-disturbance
AFB - Air Force Base
AT - Anti-tamper
AVLM - Anti-Vehicle Land Mine
BFD - Battery Firing Device
BUT - Back-up Timer
CKT - Circuit
CM - Centimeter
DET - Detonator
DM - Dimple Motor
DOD - Department of Defense
DS - Dial Shutter
EAT - Electrical Arming Timer
ED - Event Delay
EMF - Electromotive Force
EOD - Explosive Ordnance Disposal
ET - Explosive Train
FAR - Failure and Analysis Report
FMU - Fuze Munition Unit
G - Acceleration, due to Gravity
GM - Gram
GR - Grain
HE - High Explosive
Hz - Hertz
ICM - Initiation Circuit Module
ILA - In-Line Arming
ILAT - In-Line Arming Timer
IM - Impact Memory
KIAS - Knots Indicated Airspeed
LVSD - Low Voltage Self-Destruct
MOD - Modification
Msec - Millisecond
PA - Piston Actuator
PAS - Power Arming Switch
PIT - Pre-Impact Timer
RF - Radio Frequency
S&A - Safe and Arm
SC - Self-Check
SCR - Silicon Controlled Rectifier
Sec - Second
Spec - Specification
SS - Selector Switch
TCM - Timing Circuit Module
TEMP - Temperature
TES - Terminal Environment Sensor
vdc - Volts dc
WAAPM - Wide Area Anti-Personnel Mine
μa - Microampere
μsec - Microsecond
$\leq$ - Not Greater Than
$\geq$ - Not Less Than

SECTION I

INTRODUCTION

A. DESCRIPTION

The FMU-63/B Long Delay Bomb Fuze (Figure 1) has been designed to be used in either the nose or tail well positions of retarded and/or non-retarded bombs. The FMU-63/B fuze is capable of utilizing mechanical initiation (common to Air Force bombing systems) or electrical initiation (common to Navy bombing systems). Delay settings, ranging from 1.0 hour to 199 hours, are provided.

The fuze assembly is approximately 6-1/2 inches long [not including the battery firing device (BFD)] and 2-7/8 inches in diameter; attachment of the mechanical BFD adds approximately 2-1/4 inches to the length. The shipping configuration includes two red warning tags that indicate the presence of the safe pin and BFD locking pin, a bomb nose, closure ring, and a MAU-162/A firing lanyard adjuster.

The selectable delay time is visible in two openings (windows) on the front of the fuze. The red warning tag connected to the handle of the safe pin on the front of the fuze is the safe pin warning flag. The safe pin extends (internally) through the length of the fuze container. When the safe pin is fully inserted, approximately 1/4 inch of the tip can be observed through a viewing window located on the aft end of the container.

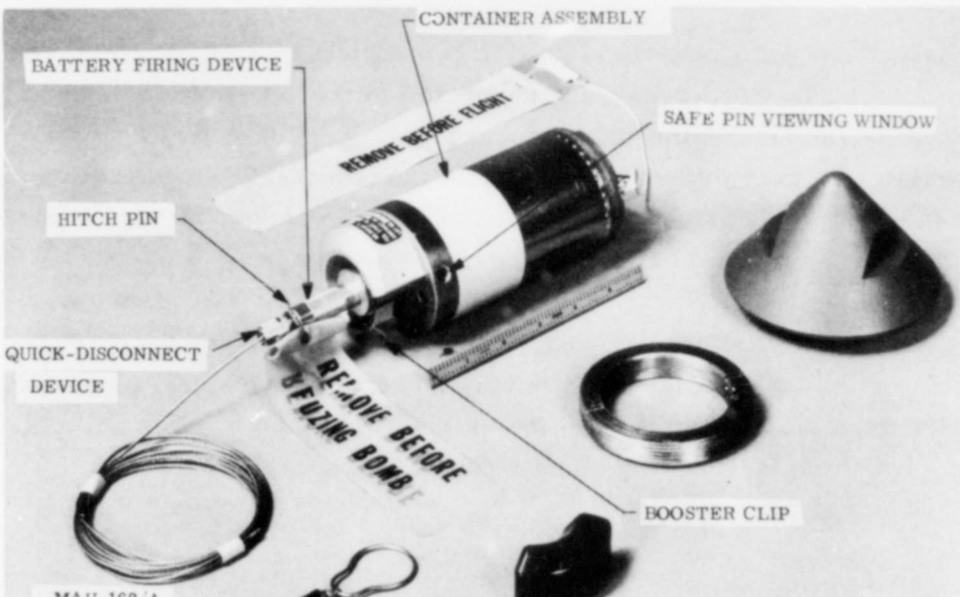
The battery firing device is threaded into the aft end of the fuze container. It contains the lanyard assembly quick disconnect device and the hitch pin with its associated warning tag. The hitch pin prevents accidental cocking and firing of the BFD during storage and handling periods.

Safety Features

Safety features of the FMU-63/B Bomb Fuze include:

(1) A safe setting on the selector switches which automatically duds the fuze if internal power is initiated.

a. Nose End



b. BFD End

Figure 1. FMU-63/B Bomb Fuze

(2) A safe pin which retains the detonator (S&A interrupter) of the explosive train in the out-of-line position until the pin has been removed.

(3) A viewing window to observe the proper position of the safe pin.

(4) Arming decision logic which delays the final mechanical arming (in-line explosive train) until 20 minutes after release.

(5) A logic circuit to dud the fuze unless a satisfactory signal sequence and level is delivered from the sensors.

(6) Self-check features that automatically dud the fuze if certain logic is out of sequence (impact memory prior to run-out of the pre-impact timer).

(7) A dial shutter circuit which denies visible access to the selected delay setting time and safe pin hole. When the shutters are closed, it indicates that fuze battery power has been applied to the system.

(8) A mechanical gag that locks the interrupter out-of-line until impact occurs.

(9) A sear that mechanically locks the interrupter out-of-line until immediately before fuze arming.

(10) An interrupter spring that helps hold the interrupter out-of-line until fuze arming.

(11) A mechanical battery firing device which contains a mechanical locking pin that prevents battery initiation during transportation and handling of the fuze prior to installation.

This report describes the design and development efforts expended by the contractor to provide the Air Force with a reliable long delay bomb fuze for use in retarded or non-retarded bombs.

SECTION II

SUMMARY

The contract objective was to develop an electronic long-delay bomb fuze. The scope of work encompassed all phases of a development program including preliminary design, preparation of drawings, safety analyses, evaluation of components, performance of MIL-STD laboratory and field tests, and pre-production engineering. The initial program objective was to develop a fuze with a settable delay from 1.0 hour to 100 hours. Later contract modifications extended and modified these requirements; this resulted in a fuze design with greatly improved tactical capabilities.

The design, development, and evaluation of total fuze assemblies, components, and subassemblies were a continuing effort throughout the program life. In addition to total fuze assembly, tested components and subassemblies evaluated during the FMU-63/B program included:

1. Anti-disturbance switches
2. Batteries
3. Battery firing devices
4. Capacitors
5. Electrochemical timers
6. Explosive trains and explosive components
7. Inertial switches
8. Resistors
9. Safe and arm assemblies
10. Selector switches
11. Silicon controlled rectifiers
12. Subassemblies (electronic modules)
13. Transistors
14. Zener diodes

The final result of the FMU-63/B Long Delay Bomb Fuze program was the delivery of a fuze designed for use in either the bomb nose or tail fuze well positions of retarded or non-retarded bombs, and which can be initiated mechanically (Air Force bombing systems) or electrically (Navy bombing systems). Delay settings (timed from moment of battery initiation) are provided that range from 1.0 hour to 199 hours. The fuze can be loaded and secured into the bomb prior to setting delay times.

Air Force test and evaluation of the final FMU-63/B fuzes was still in progress when this report was written. Therefore, final evaluation results are not included in this report.

Documents generated in support of the FMU-63/B Long Delay Bomb Fuze Program efforts include:

1. Safety Analysis of FMU-63/B Long Delay Electronic Bomb Fuze - January 1971 amended November 1971.

This report identifies seven hazard conditions and analyzes each. It is concluded that the fuze is safe; however, two potential critical failures are identified: one in safe jettison due to aircraft bombing system failure and the other due to a broaching bomb in low level delivery. Also presented are component failure mode and effect analysis and wiring short and interchange analysis.

2. Component Application List - January 1971 revised September 19, 1971.

An explanation of the purpose of each component in the fuze electronics section is given.

3. Technical Data for Storage and Maintenance Procedures - October 1971

This data includes a description of, and instructions for, safe and proper storage, handling, inspection, testing, maintenance, and preparation for use of the fuze and associated components.

4. Technical Data for Loading Procedures - August 1971

Instructions for installing the fuze in a bomb are included in this document.

5. Reliability Prediction - (Confidential Report) Revised October 1971.

This report is concerned with the prediction of the operational reliability of the fuze, over the -55°C to +72°C temperature range, with settings to maximum event time delay.

6. Computer Aided Circuit Analysis (Confidential Report)

Equations are presented in terms of circuit parameters derived from the equivalent circuit models. It is concluded that the design is adequate for all conditions where data was available.

7. Value Engineering Report - Submitted January 1972

The results of a 400-hour value engineering study on the final fuze configurations are presented. Certain performance tradeoffs which can be made to reduce the cost of the production line fuze are discussed.

SECTION III

TECHNICAL DISCUSSION

A. BACKGROUND

The original purpose of this contract was the design, development, and testing of an electronic, long-delay bomb fuze, incorporating an electrochemical timing unit. Within this purpose, the objective was to develop a fuze with a settable delay from 1.0 to 100 hours, in increments of 0.5 to 5 hours, 1.0 to 14 hours, 2.0 to 26 hours, 3.0 to 38 hours, 4.0 to 50 hours, and 5.0 to 60 hours. Other settings required were 100 hours and maximum. In the maximum setting, it was required that fuze function should occur upon degradation of the power supply to a minimum energy level. Later contract modifications extended and modified these objectives, extending the fuze design to include greatly improved tactical capabilities.

1. Previous Development

The electrochemical (E-cell) timing concept was investigated under a previous contract [AF 08(635)-3745, Modification 4] to replace a magnetic oscillator, magnetic decade-counter, and binary magnetic counter in the pre-settable event-delay circuit of the FMU-35/B fuze. The purpose of the replacement was to reduce manufacturing costs.

The heart of the E-cell Timing System is the E-cell, (a trade name applied to coulometric timers manufactured by Bisset-Berman Division of Plessy, Inc.) or electrochemical timing unit, which is a type of coulometer. The principle of operation of coulometers, in general, is an application of Faraday's law of electrolysis, which states in effect that an electric current will liberate metal from a surface in an amount proportional to the current and time of current flow. In a coulometer, Faraday's law is applied to the measurement of the quantity of material transferred from an anode to a cathode when a current is passed across them through an electrolyte.

Electrochemical timers are coulometers in which a known amount of metal, previously plated on an anode, is discharged in a prescribed time with a prescribed current. A sharp increase in voltage occurs when all of the plating has been transferred to the cathode. (The voltage rise is caused by the increase in the resistance of the elecyrolyte when the ions in solution are exhausted.) Typical operating EMF for an electrolytic timer is less than 50 millivolts. (The term "E-cell Timer" as used herein refers to the E-cell and associated circuitry.)

2. The E-Cell Timer

The E-cell developed for the FMU-35/B was a small metal capsule containing two electrodes and an electrolyte. Two E-cells were used to provide the selection of delay time-outs required for this fuze. Sixteen timing resistors, selectable singly or in combination, provided the required currents to E-cell E1 for time-outs ranging from 1.0 hour to 12 hours.

Another group of 19 timing resistors, selected singly or in combination, provided the required currents to E-cell E2 for time-outs ranging from 13 to 72 hours. These resistors were paralleled with a resistor which was hardwired to E2 and served as the timing resistor for the 100-hour back-up timing.

When all the platable material had been transferred from the anode to the cathode, the voltage across the E-cell increased suddenly and triggered the transistor circuitry. The output pulse from the amplifier gated the event SCR "on" to fire the detonator.

3. E-Cell Concept

The work performed under Contract AF08(635)-3745 produced an E-cell version of the FMU-35/B fuze (identified as Configuration I in this report), which was documented in Section VII of that contract's Technical Report AFATL-TR-67-80.

A comparison of the block diagrams (Figures 2 and 3) for the original FMU-35/B fuze and the E-cell fuze shows the simplification that resulted from the modification.

B. CONFIGURATIONS I AND II

1. Scope of Work

The initially contracted FMU-63/B program consisted of two parts: fuze testing (Part I) and component testing (Part II). Under Part I, 300 fuzes were to be fabricated, in lots of 50, 50, 50, and 150, with each lot successively incorporating modifications to the fuze based on evaluation of the previous lot by Eglin Air Force Base. The modifications resulting from these tests would culminate on a production engineering model of the FMU-63/B. Under Part II, test modules of the power supply, E-cell, and sensing circuitry would be fabricated and tested by Honeywell. These tests would qualify and define the major components and subassemblies of the fuze in production-lot quantities.

2. Development Activity

Initial efforts, beginning in February 1967, were spent on simplification of the fuze design. At the sponsor's request, a cost study was made of: (1) Configuration I, as defined in the drawing package; (2) Configuration II, a production-engineered model that had been built as a result of study under FMU-35/B contract and shown to the sponsor; and (3) a proposed configuration incorporating certain aspects of Configuration II concepts into a lower cost item, including circuit changes and other cost-saving design changes (Configuration III). From the results of the study, it appeared that more than $20.00 per unit could be saved by using the Configuration II design, with even more savings possible using the Configuration III design.

In anticipation of Air Force approval of the Configuration III design, most of the development work was suspended. Work continued on the E-cell,

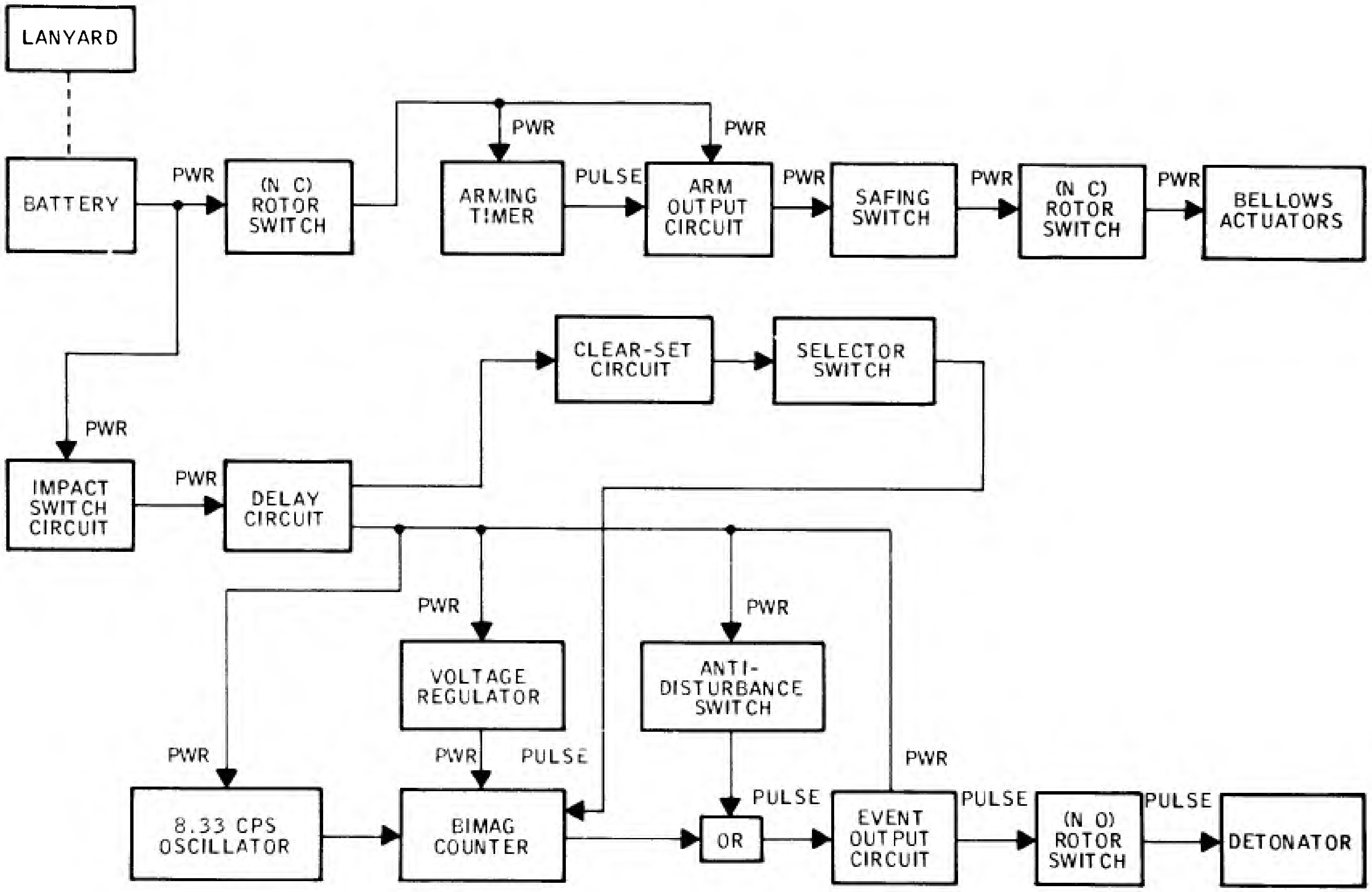


Figure 2. Block Diagram of FMU-35/B Long Delay Bomb Fuze

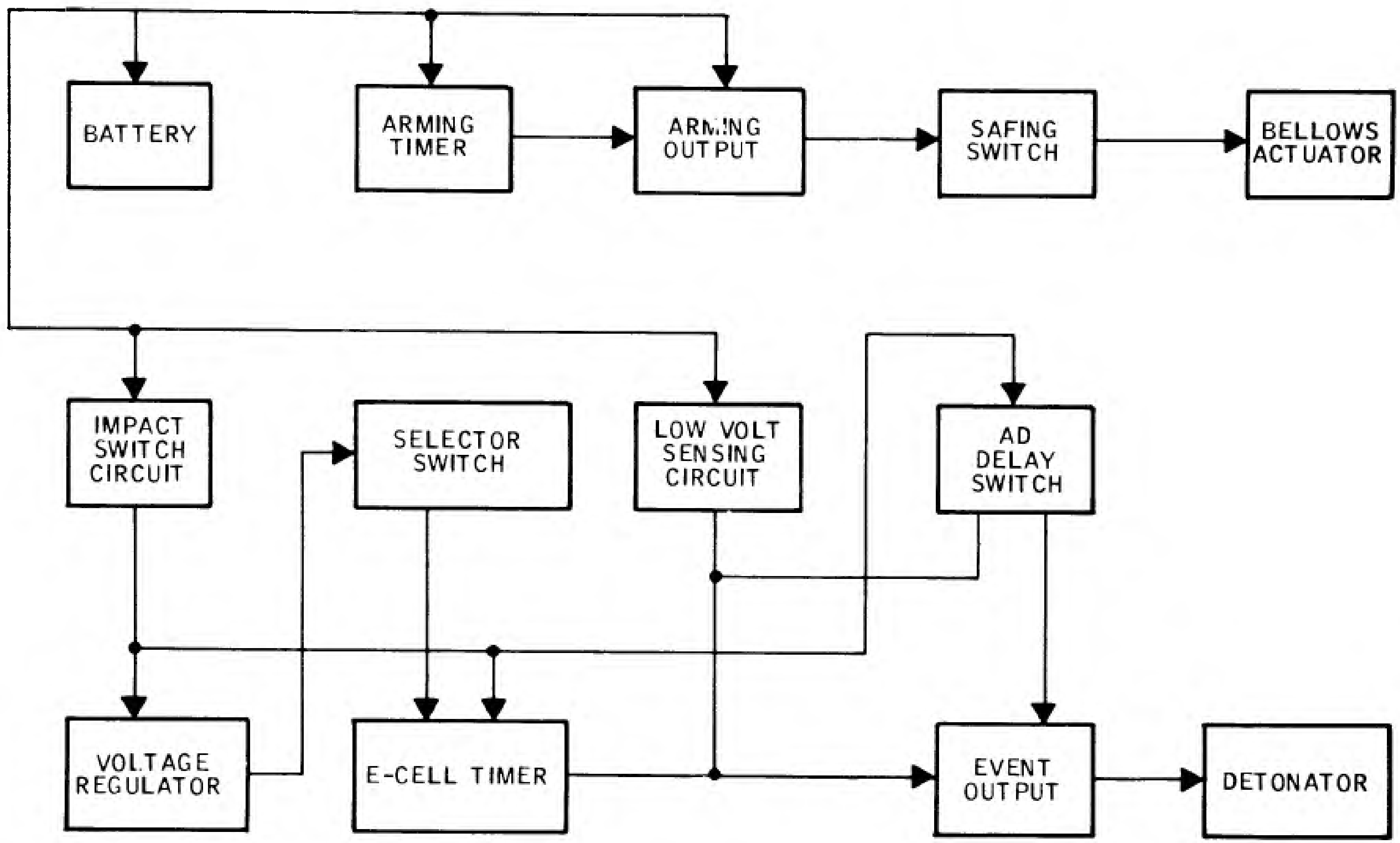


Figure 3. Block Diagram of E-Cell Fuze

battery, flight monitor system, and changes experienced in the Anti-Vehicle Land Mine (AVLM) and Wide Area Anti-Personnel Mine (WAAPM) programs were incorporated into the E-cell build. All batteries required for the battery test programs and the initial 50-fuze build were fabricated.

A revised scope of work was proposed after the sponsor indicated preliminary acceptance of the design changes that identified Configuration III. Under the revised scope of work, costs would be reduced through changes in the electrical and mechanical concepts of the fuze without degradation of function or reliability.

C. CONFIGURATION III

1. Scope

The revised contract was instituted in June 1967. Under the terms of Part I of this revision, the number of fuzes to be fabricated was reduced to 180. Of these, 20 would be tested by Honeywell and 48 engineering models would be shipped to Eglin Air Force Base for evaluation. Based on the results of the Air Force evaluation, any necessary design changes would be made, and 112 fuzes would be fabricated on a pilot-production assembly line. Lot-sample tests would be conducted on 10 of these, and the remaining 102 units would be delivered to Eglin Air Force Base for evaluation. After failure-mode determination and any corrective action, production engineering input would begin.

Part II of the new contract required the design and fabrication of 200 E-cell test modules containing a new functional circuit, testing of these modules using factorial test procedures, delivery of 100 E-cells and 14 liquid-ammonia batteries, evaluation of the 50 batteries built during the Configuration I program, purchase of 2000 E-cells, and evaluation of 576 E-cells using factorial test procedures.

Contract Modification P001, received in July 1967, confirmed the revised scope of work.

2. Design and Development

a. General - In its first form, Configuration III utilized the 36-position delay setting mechanism of Configuration I with a different dial. The same battery, battery firing device (BFD), and BFD/booster fixture were also used. A safing pin and an anti-disturbance (AD) function augmentation device were added. The work was expanded to incorporate changes resulting from FMU-26/B experience in Vietnam and from FMU-35/B production problems. These changes involved a better anti-rotation locking feature (fuze retainer) during fuze installation and improved electronic checkout procedures. A better detent stop was also put into the breadboard model.

In August 1967, design studies were initiated at the request of the project officer for circuit changes which would provide the following fuze features:

- A dudding function if no impact should occur within a specified time after battery initiation.
- A short time delay after receipt of the event fire signal.
- Initiation of the long time delay circuit from the impact-sensing circuit rather than directly from the battery-voltage rise.
- A maximum time-out setting which would have 90 percent reliability at nominal room-temperature conditions.
- A hard-wired backup timer in case of selector-switch failure.

Incorporation of these changes would require 22 new components and associated wire changes, as well as a new packaging layout.

Two basic studies were started in September 1967 to make the fuze adaptable to retarded bombs (1) a safing switch with appropriate bypass devices, and (2) deletion of the safing switch, with its function to be fulfilled by other devices.

In October 1967, final assembly of the 20 Configuration III fuzes was completed. Sixteen units were assembled with dimple motors replacing the

detonators in the explosive-train assembly, and four units contained activated AD circuitry. The first phase of the evaluation program was conducted, with the following results:

- The overall circuitry showed stable performance over the environments tested.
- Voltage regulation was within specification at all times.
- The timing components (other than the E-cell) low-voltage self-destruct, and output circuit functioned properly.
- The O-ring seal configuration had no detectable water leakage after 120 hours at 50 feet of equivalent pressure.

In December 1967, evaluation of the 20 Configuration III fuzes was continued through high-impact tests. Of four units subjected to the high-impact test, two performed satisfactorily, one was damaged because the dummy booster had been omitted, and one failed to initiate. In the unit that failed to initiate, the gas generator on the battery had not functioned and was found to have ammonia in it. The impulse in these tests consisted of (1) air-gun velocity shock of approximately 900 fps with the battery firing device forward (simulating nose-well installation), (2) free-flight and sabot impact into a wall of hay bales, and (3) backup impact into loose sand. The results of this evaluation are summarized in Table I.

The four impact-tested units were rebuilt and subjected to jolt-and-jumble evaluation with satisfactory results. The E-cells of the remaining 16 Configuration III units were replated and the units submitted to electronics retesting. Only one of four passed the -65°F. run, and only one of four passed the room-temperature test after 21 hours of thermal shock. No units were completely satisfactory at room temperature or +165°F. Preliminary failure analysis revealed critical defects, and a study was undertaken which would correct the deficiencies. As a result of the study initiated in September 1967, Configuration IV was proposed, and Configuration III was discontinued. The jolt-and-jumble evaluation and electronic retests are summarized in Table II.

TABLE I. EVALUATION OF 20 CONFIGURATION III FUZES

LOT	S/N	TYPE OF TEST(S)	TEST RESULTS	COMMENTS
A	1 2 3 4	FUNCTION AT ROOM TEMPERATURE	ALL FIRST-RUN TESTING COMPLETED IN NOVEMBER - SAFING SWITCH, S/N 3 AND 4, "KICKED OUT" ON ACCIDENTAL DROP PRIOR TO TEST. ALL UNITS WENT GREATER THAN 10 DAYS TO LVSD.	E-CELLS HAVE BEEN REPLATED FOR FUNCTIONAL RETEST OF THE FUZE ELECTRONICS.
B	5 6 7 8	WATERPROOFNESS (WITH DETONATORS)	ALL FIRST-RUN TESTING COMPLETED IN NOVEMBER - NO DETECTABLE WATER LEAK AFTER 120 HR AT 50 FT WATER PRESSURE.	UNITS WERE DISASSEMBLED WITHOUT BATTERY ACTIVATION BECAUSE OF MISASSEMBLY OF E-CELLS. UNITS HAVE BEEN REBUILT FOR JOLT AND JUMBLE TESTING.
C	9 10 11 12	.HIGH SHOCK	ALL FIRST-RUN TESTING COMPLETED IN DECEMBER - S/N 9 - INADVERTENTLY IMPACTED WITHOUT DUMMY BOOSTER; BOTH BATTERY AND ELECTRONICS PERFORMED NORMALLY. S/N 10 - BATTERY FAILED TO INITIATE. S/N 11 - PERFORMED SATISFACTORILY. S/N 12 - PERFORMED SATISFACTORILY.	E-CELLS HAVE BEEN REPLATED FOR FUNCTIONAL RETEST OF THE FUZE ELECTRONICS.
D	13 14 15 16	HIGH TEMPERATURE	ALL FIRST-RUN TESTING COMPLETED IN NOVEMBER - S/N 13 - DID NOT EVENT. BATTERY RUN DOWN BY DUD CHARACTERISTICS OF THE ELECTRONICS. S/N 14 - EVENTED AT 26.2 HR. S/N 15 - SAME AS S/N 13. S/N 16 - SAME AS S/N 13.	THE THREE DUDS WERE CAUSED BY THE MISASSEMBLY OF THE E-CELLS. THE E-CELLS HAVE BEEN REPLATED FOR FUNCTIONAL RETESTS OF THE FUZE ELECTRONICS.
E	17 18 19 20	LOW TEMPERATURE	ALL FIRST-RUN TESTING COMPLETED IN NOVEMBER - S/N 17 - IGNITER FIRED. BATTERY FAILED TO COME UP. S/N 18 - LVSD AT 94 HR. BATTERY FAILED. S/N 19 - LVSD > 150 HR. S/N 20 - LVSD > 150 HR.	E-CELLS HAVE BEEN REPLATED FOR FUNCTIONAL RETESTS OF THE FUZE ELECTRONICS.

TABLE II. RETEST OF 20 CONFIGURATION III FMU-63/B FUZES

TEST SERIES	S/N	ENVIRONMENT	ARMING TIME	IMPACT DELAY (EC-2)	COMMENTS	NTG (EC-1)	COMMENTS	NTG (EC-3)	COMMENTS
A	1	RUN AT ROOM TEMPERATURE	ALL FUNCTIONED SATISFACTORILY	LONG 10% OVER ALLOWABLE	NOTE A	FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY	
	2			FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY		DUD	EC-2 DEVELOPED A SHORT DURING THIS TIME OUT RESULTING IN A DUD
	3			NO TIME OUT	EC-2 SHORTED	DUD	EC-2 SHORTED	DUD	EC-2 SHORTED
	4			LONG 20% OVER ALLOWABLE	NOTE A	EC-1 WOULD NOT TIME OUT	EVSD FUNCTIONED	LONG 194% OVER SETTING	EC-3 APPEARED TO BE TEMPORARILY SHORTED
C	7*	RUN AT -65°F	ALL FUNCTIONED SATISFACTORILY	FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY	
	9			WAS NOT ABLE TO MEASURE DUE TO BROKEN TEST LEAD IN FUZE.		SHORT 20% UNDER SETTING	NOTE A	THIS UNIT WAS AIR GUNNED AT HDPG. SELECTOR SWITCH WAS JAMMED, THEREFORE COULD NOT TIME OUT OTHER E-CELL.	
	10			SHORT	NOTE A	SHORT 34% UNDER SETTING	NOTE A	SHORT 18% UNDER SETTING	NOTE A
	12			SHORT	NOTE A	FUNCTIONED SATISFACTORILY		SHORT	NOTE A
D	13	RUN AT +165°F	ALL FUNCTIONED SATISFACTORILY	SHORT 1.3% UNDER ALLOWABLE	NOTE A	FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY	
	14			FUNCTIONED SATISFACTORILY		LONG	BOTH EC-1 AND EC-3 TIMED OUT TOGETHER DUE TO A SHORT IN THE SELECTOR SWITCH	ALREADY TIMED OUT	DUE TO SHORT
	15			LONG 1% OVER ALLOWABLE	NOTE A	DUD	EVENT SCR DEFECTIVE	DUD	EVENT SCR DEFECTIVE
	16			FUNCTIONED SATISFACTORILY		LONG	BOTH EC-1 AND EC-3 TIMED OUT TOGETHER DUE TO A SHORT IN THE SELECTOR SWITCH	ALREADY TIMED OUT	DUE TO SHORT
E	17	TEST AT ROOM TEMPERATURE AFTER 21 HOURS OF THERMAL SHOCK	ALL FUNCTIONED SATISFACTORILY	FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY	
	18			FUNCTIONED SATISFACTORILY		FUNCTIONED SATISFACTORILY		DUD	EC-2 DEVELOPED A SHORT DURING THIS TIME OUT RESULTING IN A DUD
	19			FUNCTIONED SATISFACTORILY		SHORT 98% UNDER SETTING	SELECTOR SWITCH INSTALLED 180° OUT OF PHASE --WAS TIMING ON WRONG E-CELL. SELECTOR SWITCH ALSO INTERMITTENTLY SHORTED.	LONG 338% OVER SETTING	SELECTOR SWITCH 180° OUT OF PHASE AND INTERMITTENTLY SHORTED
	20			FUNCTIONED SATISFACTORILY		SHORT 42% UNDER SETTING	NOTE A	FUNCTIONED SATISFACTORILY	
B	5 6 11 8	JOLT AND JUMBLE	ALL UNITS PASSED THIS TEST						

* S/N 11 REPLACED S/N 7 IN JOLT AND JUMBLE TEST BECAUSE OF WIRING PROBLEM.
S/N 7 USED IN ELECTRONICS RETEST OF LOT C.

NOTE A: PROBABLY DUE TO INACCURACY OF IN-HOUSE PLATING.

In February 1968, the Configuration III electronics assemblies that had been used in the fuzes that failed in air-gun tests were function tested. Results showed that normal function would have occurred. (Calculations indicated that g levels as high as 17,000 peak may have occurred during the hard-target tests.)

b. Liquid-Ammonia Battery - In August 1967, tests were started which would yield data on (1) limited low-temperature exposure, (2) degradation of cold voltage with time, and (3) safety of the design under dead short. The test units were 23 rejected FMU-35/B production batteries, the original failure mode of which would not invalidate the new test data. These tests were successfully completed in September 1967.

c. E-Cells - Between June and September 1967, 43 of 47 test E-cells for the long-delay timer had timed out to 120 hours (within specification) at +165°F., room temperature, and -56°F. The four failures were due to unsatisfactory test equipment and procedures.

The E-cell for the arming delay, on the other hand, repeatedly timed-out short during low-temperature, upper limit current operations. In August 1967, the vendor requested a tolerance change from $\pm$ 3 percent to +3, -7 percent for this E-cell (S107A), while continuing attempts to attain the original required values at temperatures below -40°C. A release was not given for the looser tolerance because of an expected revision of E-cell capacity for Configuration IV.

In November 1967, testing of Configuration III fuzes was completed except for high shock. Units in all lots failed because two of the E-cells had been interchanged in the potted assemblies: the arming delay cell (4 microampere-hours) and the long-delay cell (540 microampere-hours). To correct this situation, color codes were adopted: black bands for the two 4 μa-hour cells (EC-1 and EC-3) and red bands for the 540 μa-hour cells (ED-2 and EC-4).

In December 1967, new quality controls by the E-cell vendor improved the product; however, the low-capacity units still failed to show the desired accuracy. One of the problems found was electrolyte deterioration during sequential plating in production batches. In March 1968, a study led to the conclusion that 60 μa-hour E-Cells could be used in place of the 4 μa-hour cells without sacrificing system performance.

d. Flight Monitor – In July 1967, 128 flight monitor items which had been in fabrication since January 1967 were completed and shipped to Eglin Air Force Base. A document showing recommended procedures for use with the FMU-63/B fuzes was also completed and sent to the project officer.

D. CONFIGURATION IV

1. Scope

Contract amendment P002, 24 October 1967, specified revision of the Configuration III circuit to provide system redesign primarily for:

- Retard mode
- Event delay (space requirement only)
- Dudding window
- Hard-wire backup
- In-bomb setting capability.

Part I of amendment P002 required:

1. Evaluation of the 20 Configuration III fuzes fabricated under amendment P001.
2. Fabrication of 58 fuzes for evaluation at Honeywell and any necessary subsequent design changes.

3. Fabrication of 60 fuzes on a pilot production line, 10 to be evaluated at Honeywell, and 50 to be shipped to Eglin Air Force Base for evaluation.

4. Fabrication of another 160 fuzes on the pilot production line, 10 to be lot-sample tested at Honeywell, and 150 to be delivered to Eglin Air Force Base for evaluation.

Part II of amendment P002 required:

1. Completion of the remaining 100 of the 200 E-cell functional circuit test modules specified for fabrication under P001.

2. Completion of the P001 E-cell and test module evaluation program.

3. Delivery of 100 E-cells.

4. Development of a new BFD concept.

5. Evaluation of the explosive switch, dimple motor, and other components to prove compatibility.

a. General - In October 1967, two breadboard models of the Configuration IV electronic circuit were completed, and the first checkout runs produced satisfactory performance functions. One circuit (version N) contained a safing switch, retard sensors, and an event delay; the other circuit (version J) was a simplified version aimed at fulfilling the same requirements with equal reliability but greater economy. The breadboards were used to improve circuit performance and to search for failure functions. Both concepts were shown to be feasible and capable of being packaged in the existing envelope. The J version was proposed for the Configuration IV modification.

In January 1968 the project officer requested that Honeywell make a feasibility study of a settable arming timer. A first look indicated feasibility through the use of a selector switch on the front face of the fuze and the addition of a resistor for each desired timing value. At this time, it was also determined that the N version of the electronic circuitry would present

a packaging problem if a settable arming timer were included, since the circuit was already a tight fit.

Also in February 1968, a comparative laboratory test was completed on the performance of three types of impact switches: the standard FMU-35/B switch, a sensitized version of the same, and a Mark 128 switch (40-80 g). Vibration sensitivity scanning of the lower limits of random noise (50-2000 Hz), drop testing and centrifuge testing for the three switches gave the results shown in Table III.

TABLE III. IMPACT SWITCH TEST RESULTS.

Switch	Random Noise (g, rms)	Low Limit Centrifuge	Minimum Drop Height Steel on Steel
MK 128	19.7	72 g	1/2 inch
Sensitized FMU-35/B	21.5	83 g	1/2 inch
Standard FMU-35/B	55.0	Not available	4-1/2 inch

Data from the evaluation indicated that the end-cap modification of the standard FMU-35/B switch had a capability at least equal to that of the MK 128 switch. The advantage would be that a single FMU-35/B switch would replace two MK 128 switches at a lower cost.

b. Battery Firing Device - In October 1967, testing began on an impact-shock-resistant model of the FMU-35/B battery firing device (BFD). Satisfactory firing energy was delivered from the firing pin with a required lanyard cable pull of approximately 28 pounds. The impact-shock resistance was tested to above 3000 g, at which point the insert was sheared out of the container because the collar on the BFD was undersized. The BFD had not initiated at this point.

A reworked model of the BFD passed its first series of tests in November 1967. Shocks up to 10,000 g's were applied on the 40-foot drop tower without release of the firing pin.

c. S&A Assembly - In February 1968, simulated bomb-impact tests (air-gun) of five FMU-35/B type S&A assemblies were conducted. Two units had very little damage and completed the in-line rotation when bellows power was applied after impact. Two of the last three assemblies tested failed to fire, and all three exhibited aerodynamic instability. (Impacts were about 30 degrees out of the desired axis.) The latter deficiency was eliminated by redesigning the sabot to preclude tumbling in both forward and aft positions. Failure analysis of the two failed rotors showed that movement of one rotor had been stopped by friction resulting from housing deformation and that the bellows motors in both rotors were damaged by fracturing of the propellant and consequent breaking of the bridge wire.

In March 1968, flight tests of four units at Eglin Air Force Base (in both nose- and tail-well of the M117 bomb) showed proper function after impact. Meanwhile, computer data on impact testing were being used in concept studies of the Configuration V proposal for an impact-pulse discriminator to be used as a terminal environment sensor. A program was also started which would yield a more rugged rotor and rotor housing.

3. Summary

a. Specifications - The Configuration IV design had the following features:

- Arming time of 1.42 seconds after bomb release
- Event time settable from 1 hour to 8 days
- Four different event sources:
  - Normal selectable delay
  - Ten-day backup circuit

- Low-voltage self-destruct feature
- Anti-disturbance feature

- No event possible until several minutés after ground impact
- Usable in retarded and non-retarded munitions.

b. Safety Features – In addition to the above, the Configuration IV design had the following features to provide for safety in handling and operation:

- Automatic self-dudding if circuits should fail
- Battery state indicator to show whether power had been applied to the circuitry
- Safe pin to prevent rotor motion
- Visual indication of rotor position
- Safe setting for selector switch
- Impact-insensitive battery firing device.

c. Time Sequence – Upon release of the bomb from the aircraft, a lanyard was pulled which activated the BFD, initiating the battery. The latter immediately started the preset delay timer and the dudding timer. After 1.42 seconds, the bellows actuators were initiated, the fuze mechanically armed, and the detonator moved into line. Upon impact with the target, the impact switch closed, initiating the event delay circuit and the backup timer. The fuze would then event either upon expiration of the set delay (1 hour to 8 days) or upon disturbance of the bomb. Should the normal timer fail, a backup timer would detonate the bomb after 10 days. If, at any time prior to normal time-out, the battery should degrade to such an extent that insufficient power was available to initiate the detonator, the low voltage self-destruct circuit would be activated and would detonate the bomb immediately.

E. CONFIGURATION V.

1. General

At a design review in January 1968, Honeywell demonstrated a breadboard model of the J version of Configuration IV and also presented schematics of the FMU-63/B redesigned to arm mechanically and electrically after impact. At this time, several considerations led to the decision to design a Configuration V. Among these considerations were: (1) accommodation of after-impact arming (the S&A would probably have to be redesigned); (2) a base decision was required on the use of the arm-after-impact or a delayed arming selector (if both nose and tail well use would be required, the existing rotor design would not meet the arm-after-impact requirement); and (3) the project officer requested that a method for EOD personnel to defeat the fuze be studied. Although parts fabrication for the Configuration IV engineering models was nearly completed, assembly of these units was withheld pending revision of the scope of work.

In February 1968, the project officer defined the following requirements for Configuration V:

- Addition of a safing pin to the lanyard at the charging well
- Provision of an integral BFD
- Increased structural strength of the fuze
- Simplified switching at the rotor/shutter
- Provision of an arm-after-impact capability
- Provision of selectable arming-enabling time delays.

The Air Force Safety Review Board, after a presentation by Honeywell on Configurations III and IV-J, recommended:

- Arming after impact
- Dudding by firing the detonator out of line (detonator not to be shorted in the out-of-line position)
- Placing a mechanical restraint on the rotor until after safe separation (i.e., until impact).

In March 1968, a block diagram of Configuration V was made and physical layouts were begun. Primary efforts were in the areas where no changes were expected (i.e., independent subsystems, e.g., voltage regulator, settable arming timer, and a basic timing circuit). A request was received to make the FMU-63/B fuze acceptable to the Navy, and an informal proposal to that end was submitted to the project officer.

2. Scope of Work

Contract amendment P003, issued on 17 October 1968, specified work to be performed as indicated below:

Part I - Fuze Testing

1. Furnish a preliminary design data package. The package will include the results of preliminary reliability, safety, and failure mode studies, as well as fabrication and evaluation experience gained from module and subsystem work.
2. Procure parts for the fabrication of 28 engineering-model fuzes.
3. Complete the preliminary documentation package.
4. Provide production-engineering input, including planning for the delivery of 105 service-test models. Service-test models will contain:
    - (a) Detonators and lead cups
    - (b) Active AD features
    - (c) Inert boosters
    - (d) Air Force BFDs
    - (e) No instrumentation leads.

Part II - Component Testing

Conduct a test program to better qualify and define, under production-lot sizes, the most pertinent components and subassemblies of the FMU-63/B fuze.

1. Provide detail design and fabrication of the following subsystems and modules:

   (a) Mechanical BFD

   (b) Electrical BFD to adapt fuze to USN electrical initiation system.

   (c) New mechanical S&A system

   (d) Initiation-circuit modules

   (e) Timing-circuit modules

   (f) One complete set of mechanical piece parts to confirm fit and function.

2. Evaluate the following, and provide preliminary test data 90 days after receipt of contract:

   (a) Fifty existing timing-circuit modules

   (b) Mechanical BFDs.

3. Deliver the following items to AFATL within 90 days after receipt of contract:

   (a) Ten initiation-circuit modules

   (b) Two mechanical BFDs

   (c) Two electrical BFDs

   (d) One hundred E-cells

   (e) Ten timing-circuit modules.

4. Procure piston actuators and selector switches for qualification testing. Provide preliminary qualification test results of one type each of E-cell and selector switch, and three types of piston actuators.

Contract amendment P004, dated 24 October 1968, amended the ASPR clause of the contract and amendment P005, dated 14 November 1968, amended Exhibit ATW67-20 of the contract. These were "no cost" amendments to the contract.

Amendment P006, dated 7 April 1969, added to the contract the recorder instrument design and a two-month laboratory and field investigation of sensors for the terminal environment sensor (TES).

The terminal environment sensor laboratory and field investigation is described in Appendix I.

Amendments P007 and P008 revised the contract to provide the materials and services indicated in Table IV.

At a meeting held at Eglin AFB on 19 August 1969, AFATL and Honeywell conferees negotiated Modification P009. Modification P009 design changes were concerned with the electronic circuitry, including:

(1) Incorporating an explosive squib switch as an arm-and-fire enable element

(2) Adding a mechanical-locking sear to the explosive-train interrupter to hold it out of line in all prearm and dudding modes

(3) Eliminating the initiation of the firing actuator in the dudding mode

(4) Separating the arming and firing circuits

(5) Shorting firing-circuit power directly to ground in all dudding modes

(6) Revising the anti-tamper circuit to permit a safe position on the selector switch without event power available

(7) Relocating the firing of the battery-state indicator

(8) Revising the event-delay circuit.

TABLE IV. SCOPE OF WORK TASKS, CONTRACT AF-0051 (MODIFICATION P007)

CONTRACT LINE ITEM NO.	TASK DESCRIPTION
5	FABRICATE AND DELIVER 28 FUZES FROM PREVIOUSLY PURCHASED MATERIALS AND PROVISIONS.
4	DESIGN, FABRICATE, AND DELIVER 50 LIQUID AMMONIA BATTERIES USED IN THE FMU-63 / B
3f	TEST THE 50 BATTERIES AND CONDUCT PERFORMANCE EVALUATION UNDER EXTREME ENVIRONMENTAL EXPOSURES.
3a	TEST 50 TIMING-CIRCUIT MODULES PURCHASED WITH THE SHORT-TERM E-CELL.
3b	TEST 80 PREVIOUSLY PURCHASED, INITIATION-CIRCUIT MODULES.
3c	TEST 20 PREVIOUSLY PURCHASED, MECHANICAL S&A DEVICES.
3d	TEST 20 PREVIOUSLY PURCHASED, ELECTRICAL BFD ADAPTERS.
3e	PERFORM QUALIFICATION TESTING ON THE ONE REMAINING E-CELL PREVIOUSLY PURCHASED. DELIVER 50 E-CELLS TO AFATL / ATWB FOR GOVERNMENT TESTING
3g	COMPLETE THE QUALIFICATION TESTING ON THE SEVEN ELECTRONIC COMPONENTS PREVIOUSLY PURCHASED
6	FABRICATE AND DELIVER 105 SERVICE-TEST-MODEL FUZES USING TOOLING AND MATERIALS PREVIOUSLY PROVIDED. DELIVER 75 OF THESE FUZES TO AFATL / ATWB FOR GOVERNMENT TESTING
3l	CONDUCT LOT TESTS ON 10 OF THE FUZES FABRICATED UNDER LINE ITEM 6.
3k	CONDUCT EVALUATION TESTS ON 20 OF THE FUZES FABRICATED UNDER LINE ITEM 6.
7	FABRICATE AND DELIVER TWO FUNCTIONAL DEMONSTRATOR MODELS AND ONE CUTAWAY MODEL OF THE FMU-63 / B FUZE TO AFATL / ATWB.
9	AFTER OBTAINING APPROVAL OF THE DESIGN SUBMITTED AS ENGINEERING DATA UNDER LINE ITEM 240 OF DD FORM 1423, FABRICATE AND DELIVER 290 LIVE AND INERT PROTOTYPE FUZES AS FOLLOWS a. 250 LIVE AND INERT TO AFATL / ATWB. b. 10 LIVE FOR TESTING AT HONEYWELL. c. 10 LIVE FOR EOD TESTING AT NAVAL EOD FACILITY, INDIANHEAD, MD. d. 10 LIVE FUZES WITH DETONATORS AND EXPLOSIVE LEADS REMOVED FOR EOD TESTING AT NAVAL EOD FACILITY, INDIANHEAD, MD e. 10 LIVE FUZES WITH DETONATORS AND EXPLOSIVE LEADS REMOVED FOR HERO TESTING.
3h	CONDUCT LOT TESTS ON TEN OF THE FUZES FABRICATED UNDER LINE ITEM 9.
10	DESIGN, FABRICATE AND DELIVER 48 OPERATION (LIVE) FUZES FOR HAZARD CLASSIFICATION TESTING.
3i	CONDUCT HAZARD TESTS IN ACCORDANCE WITH PARAGRAPH 4.3.1 OF R&D EXHIBIT ATW 67 20C, DATED 2 DECEMBER 1958 ON FUZES UNDER LINE ITEM 10
11	PROVIDE A VALUE ENGINEERING PROGRAM OF APPROXIMATELY 800 MAN HOURS IN ACCORDANCE WITH R&D SPECIFICATION ATW 67-20C.
8	PROVIDE 60 DAYS OF ENGINEERING-TEST SUPPORT ON THE FMU-63 / B FUZE TO EGLIN AIR FORCE BASE, FLORIDA. (X)

(X) AS REQUESTED BY SPONSOR

Modification P0010, issued 19 November 1969, modified delivery quantities for the 105 service test model fuzes, as indicated in Table V.

Assembly of the 28 engineering model fuzes was completed in September 1969. One of these fuzes was delivered to AFATL, and the remaining 27 were subjected to evaluation tests by the contractor. The following defects were uncovered in these tests:

(1) Improper assembly techniques caused out-of-tolerance performance from the time base component

(2) Vibration and shock caused degradation of the anti-disturbance feature

(3) Insulation on wiring cracked from aging

(4) Two transistors failed due to mechanical shock

(5) Battery performance degraded by structural failure from high level mechanical shock

(6) Ball seal did not function properly

(7) Printed wiring boards were of poor workmanship and had not been adequately inspected and tested

(8) Tantalum capacitors were of poor workmanship

(9) Inadequate soldering methods caused two failures

(10) One firing actuator failed due to excessive high g mechanical shock

(11) Structural failure of battery sleeve caused seal failures.

On 18-20 November 1969, an Air Force Design and Safety Review was conducted at the contractor's facilities under the direction of the AFATL. Prime critiquing conferees, in addition to those from AFATL, were representatives from AFRDDA, ADDS, Rome Air Development Center, Norton AFB, and Nellis AFB. Representatives from NAVAIR, Naval Ordnance Laboratory, White Oak, Maryland, and the Naval Weapons Laboratory, Dahlgren, Virginia, attended to be brought up to date on the latest fuze

TABLE V. STATUS OF SCOPE OF WORK TASKS CONTRACT AF-0051 (MODIFICATION P0010)

CONTRACT LINE ITEM NO.	TASK DESCRIPTION
5, 3j	FABRICATE AND DELIVER (1) 28 FUZES FROM PREVIOUSLY PURCHASED MATERIALS AND PROVISIONS & TEST (2)
4	DESIGN, FABRICATE, AND DELIVER 50 LIQUID AMMONIA BATTERIES USED IN THE FMU-63 / B
3f	TEST THE 50 BATTERIES AND CONDUCT PERFORMANCE EVALUATION UNDER EXTREME ENVIRONMENTAL EXPOSURES
3a	TEST 50 TIMING-CIRCUIT MODULES.
3b	TEST 80 PREVIOUSLY PURCHASED, INITIATION-CIRCUIT MODULES.
3c	TEST 20 PREVIOUSLY PURCHASED, MECHANICAL S&A DEVICES.
3d	TEST 20 PREVIOUSLY PURCHASED, ELECTRICAL BFD ADAPTERS.
3e	PERFORM QUALIFICATION TESTING ON THE ONE REMAINING E-CELL PREVIOUSLY PURCHASED. DELIVER 50 E-CELLS TO ADTC/ADDF FOR GOVERNMENT TESTING.
3g	COMPLETE THE QUALIFICATION TESTING ON THE SEVEN ELECTRONIC COMPONENTS PREVIOUSLY PURCHASED.
6	FABRICATE AND DELIVER 105 SERVICE-TEST-MODEL FUZES USING TOOLING AND MATERIALS PREVIOUSLY PROVIDED. DELIVER 81 OF THESE FUZES TO ADTC/ADDF FOR GOVERNMENT TESTING
3l	CONDUCT LOT TESTS ON 4 OF THE FUZES FABRICATED UNDER LINE ITEM 6.
3k	CONDUCT EVALUATION TESTS ON 20 OF THE FUZES FABRICATED UNDER LINE ITEM 6.
7	FABRICATE AND DELIVER TWO FUNCTIONAL DEMONSTRATOR MODELS AND ONE CUTAWAY MODEL OF THE FMU-63 / B FUZE TO ADTC / ADDF.
9	AFTER OBTAINING APPROVAL OF THE DESIGN SUBMITTED AS ENGINEERING DATA UNDER LINE ITEM 240 OF DD FORM 1423, FABRICATE AND DELIVER 290 LIVE AND INERT PROTOTYPE FUZES AS FOLLOWS a. 250 LIVE AND INERT TO ADTC / ADDF. b. 10 LIVE FOR TESTING AT HONEYWELL. c. 10 LIVE FOR EOD TESTING AT NAVAL EOD FACILITY, INDIANHEAD, MD. d. 10 LIVE FUZES WITH DETONATORS AND EXPLOSIVE LEADS REMOVED FOR EOD TESTING AT NAVAL EOD FACILITY, INDIANHEAD MD e. 10 LIVE FUZES WITH DETONATORS AND EXPLOSIVE LEADS REMOVED FOR HERO TESTING
3h	CONDUCT LOT TESTS ON TEN OF THE FUZES FABRICATED UNDER LINE ITEM 9.
10	DESIGN, FABRICATE AND DELIVER 48 OPERATION (LIVE) FUZES FOR HAZARD CLASSIFICATION TESTING.
3i	CONDUCT HAZARD TESTS IN ACCORDANCE WITH PARAGRAPH 4.3.1 OF R&D EXHIBIT ATW 67-20C DATED 2 DECEMBER 1958 ON FUZES UNDER LINE ITEM 10.
11	PROVIDE A VALUE-ENGINEERING PROGRAM OF APPROXIMATELY 800 MAN HOURS IN ACCORDANCE WITH R&D SPECIFICATION ATW 67-20C
8	PROVIDE 60 DAYS OF ENGINEERING TEST SUPPORT ON THE FMU-63 / B FUZE TO EGLIN AIR FORCE BASE FLORIDA (X)1

(X)1 AS REQUESTED BY SPONSOR

configuration. Following a briefing by the contractor representatives on design and safety developments, the conference chairman named members of three teams who met for the next two days to analyze the data package in the areas of operations and design, operations and safety, and operations and testing.

As a result of the critiquing by the three teams, 28 review worksheets were issued requesting disposition. The contents of the worksheets are summarized in Table VI. As many as possible of the design change action items for which the contractor was to be responsible were to be incorporated in the building of the 105 service-test models. The table also includes an action taken and completed summary for each of the problem items.

Contract modification P0014 was received late in June 1970. This modification required incorporation of the detented gag redesign into the S&A and circuit revisions to simplify the readability of the delay time settings.

Delivery of the 81 service test fuzes was completed in June 1970. Evaluation test of 24 service test fuzes was in process by the contractor. Preliminary contractor test results of the 24 service test fuzes is presented in Table VII.

Sponsor test of 81 service test fuzes was completed early in 1971.[1] Results of these tests were analyzed to identify problem areas and action requests for presentation at the scheduled design review. A failure and analysis summary of the sponsor test of the 81 service test fuzes is presented in Table VIII.

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(1) ADTC-TR-71-62, May 1971, Development Test of the FMU-63/B Long Delay Fuze.

TABLE VI. CRITIQUE SUMMARY, AF DESIGN AND SAFETY REVIEW

WORKSHEET CONTROL NO.	FUZE COMPONENT MODULE ETC.	COMMENTS ON PROBLEM	PROBLEM EFFECTS:	(1) ADDF ACTION ITEM (2) ACTION TAKEN	(1) CONTRACTOR ACTION ITEM (2) ACTION TAKEN 31 DECEMBER
001 (RADC)	DIODE CR 19, TES MODULE	DIODE SHORTED OR REVERSED, "LO-G" SWITCH CAN FIRE CR 33 INADVERTENTLY TO ACTIVATE THE ARM AND ENABLE CKT.	SAFETY	- -	(1) (a) PROVIDE TIME-VOLTAGE CURVES OF C_2 CHARGING C_{10} - C_{11} WITHOUT DIODE. (b) PROVIDE MAXIMUM VOLTAGE ON C_2. (2) (a) DATA GATHERING AND ANALYSIS COMPLETED. (b) TO BE SUPPLIED 7 JANUARY
002 (TFWC)	E-CELL IN ILAT (ILAT BACKUP)		DESIGN SAFETY	PROVIDE SKIP BOMB BALLISTICS DATA	(1) INVESTIGATE MAXIMUM TIME DELAY, BREADBOARD & TEST. (2) STUDIES IN PROCESS.
003 (TFWC)		SELF-DESTRUCT/STERILIZATION TESTS SHOULD BE CONDUCTED AND DATA MADE AVAILABLE TO USER.	SAFETY TEST	(1) ADTC AND EOD GATHER DATA.	(1) (a) GATHER DATA, DATA TO BE GATHERED ON ALL TESTS CONDUCTED ON BUT. (b) PROVIDE BATTERY LOAD DATA. (2) IN PROCESS.
004 (TFWC)	FUZE	RELIABILITY OF 90/90 STATED IN R&D EXHIBIT SHOULD BE CHANGED TO 95/90 FOR FUZES NOSE-INSTALLED IN RETARDED WEAPONS.	RELIABILITY	(1) ADTC TEST TO DETERMINE IF R OF 95/90 EXISTS IN NOSE-FUZED, HI-DRAG BOMBS.	NONE.
005 (TFWC)	ELECTRONICS-TO-S&A WIRE CONNECTIONS	POSSIBILITY OF SHORTING OR MIS-ROUTING SHOULD BE AVOIDED; USE FLEXPRINT.	DESIGN SAFETY RELIABILITY	- -	(1) INVESTIGATE USE OF FLEXPRINT, MAKE RECOMMENDATIONS TO AF PRIOR TO PROCUREMENT FOR FUZES AFTER SERVICE-TEST MODEL BUILD. (2) SAMPLE FURNISHED 8 DECEMBER.
006 (TFWC)	FUZE ARMING	WHAT TOTAL TIME OF FALL WILL ENSURE FUZE ARMING IF RETARD-FIN OPENING RECYCLES PIT?	TECH. DATA RELIABILITY	(1) TEST TO DETERMINE PIT RECYCLING. IF THERE IS RECYCLING, INCLUDE IN T.O.-34 DATA.	(1) TEST TO DETERMINE PIT RECYCLING. IF THERE IS RECYCLING, INCLUDE IN SOURCE DATA FOR T.O. -34 DATA. (2) ACTION DEFERRED TO 338 BUILD.
007 (TFWC)	IMPACT GAG	TEN-G IMPACT GAG MUST BE TESTED TO ENSURE THAT IT WILL NOT FUNCTION DUE TO A/C VIBRATION. IF G-LEVEL IS INADEQUATE, RAISE AND ESTABLISH PROCEDURES TO CONTROL DURING PRODUCTION.	DESIGN SAFETY TEST	(1) OBTAIN WATER-IMPACT DATA FROM NAVY.	(1) TEST; REPORT DATA TO ADTC PRIOR TO 105 SERVICE-TEST MODEL ASSEMBLY. (GAG RETAINED BY GAG RETAINER PRIOR TO RUNOUT OF PIT. G-LEVEL TEST SPECIFIED IN DRWG. X68F5641 AS 10-20G STATIC EQUIVALENT.) (2) AF REQUESTED PROPOSAL TO REDESIGN BY 30 JANUARY.
008 (TFWC)	FUZE SETTING; DECAL	DECAL MUST BE CLEAR AND SIMPLE FOR SETTING TIME DELAY. NUMBERS SHOULD BE READABLE IN LESS THAN OPTIMUM CONDITIONS. DETENTS SHOULD BE POSITIVE. CONTRACTOR REPORTS NUMBERS ARE MAX. SIZE FOR EXISTING DIALS, AND SETBACK FROM FUZE FACE IS CONTROLLED BY COVERED SETTINGS REQUIREMENTS.	DESIGN HANDLING TECH. DATA	(1) ADTC CONDUCT HUMAN-FACTOR EVALUATION AND INVESTIGATE ADEQUACY OF USING X67C9168 TO ESTABLISH MAXIMUM DIAMETER OF FUZE.	(1) CONTACT VENDOR TO INVESTIGATE OPTIMUM DETENTS. (2) (a) DETENT LEVEL INCREASED IN SPECIFICATION. (b) DECAL COLOR AS REQUESTED BY ADDF INCORPORATED IN 105-UNIT BUILD.

TABLE VI. CRITIQUE SUMMARY, AF DESIGN AND SAFETY REVIEW (CONTINUED)

WORKSHEET CONTROL NO.	FUZE COMPONENT MODULE ETC.	COMMENTS ON PROBLEM	PROBLEM EFFECTS:	(1) ADDF ACTION ITEM (2) ACTION TAKEN	(1) CONTRACTOR ACTION ITEM (2) ACTION TAKEN 31 DECEMBER
009 (TFWC)	BFD'S	FACTORY INSTALLATION IS DESIRED, BUT FIELD INSTALLATION SHOULD BE POSSIBLE. CONTRACTOR: FMU-63/B CAN BE ASSEMBLED WITH EITHER BFD. FIELD INTERCHANGEABILITY IS PLANNED.	DESIGN HANDLING	- -	(1) (a) INVESTIGATE BFD RETAINER AND BOOSTER CLIP AND PROVIDE RESULTS TO ADTC BY 15 JANUARY 1970. (b) CONDUCT TOLERANCE STUDY ON SIZE OF FUZE. (2) (a) NYLOC ADDED BY E.O. MODELS IN PROGRESS. (b) STUDY IN PROGRESS.
010 (ADDS)	DIODES CR 91 AND CR 92	REMOVE DIODES TO AVOID POSSIBLE DUDDING OF FUZE IF PIT FAILS TO FUNCTION.	DESIGN SAFETY RELIABILITY	(2) DECISION WAS MADE TO RETAIN PRESENT DESIGN.	(2) DECISION WAS MADE TO RETAIN PRESENT DESIGN.
011 (ADDS)	S7.	ELIMINATE CURRENT THROUGH S7 BY TYING CONTACT 2 TO TP9 INSTEAD OF TP13.	DESIGN SAFETY	- -	1 INCORPORATE IN ALL FUTURE FUZES IN SERVICE-TEST MODELS, IF POSSIBLE. 2 INCORPORATED INTO 105-UNIT BUILD.
012 (ADDF)	FLAT-BAND CABLE	CABLE CAN SHORT IF CRUSHED, RESULTING IN SAFETY AND RELIABILITY PROBLEMS (IF PISTON ACTUATORS IN S&A FIRE IN WRONG SEQUENCE).	DESIGN SAFETY RELIABILITY	- -	SAME AS CONTROL NO. 009.
013 ADDF	BATTERY SLEEVE	PRESENT BANDING METHOD INADEQUATE; MORE POSITIVE MEANS REQUIRED.	DESIGN		1 INVESTIGATE WELDED CONSTRUCTION. 2 DESIGN INCORPORATED BY E.O. TO 105-UNIT BUILD.
014 ADDF	BOOSTER CLIP	INSTALLING AND REMOVING BOOSTER IS DIFFICULT. CLIP SHOULD BE REDESIGNED, POSSIBLY USING A DESIGN SIMILAR TO THAT USED IN FMU-81 E.	DESIGN HANDLING	- -	SAME AS CONTROL NO. 009
015 ADDF	SOLDER JOINTS	SOLDERING PISTON-ACTUATOR LEADS MAY CREATE SHORTS; A MEANS FOR INSPECTING AND DETECTING IS NEEDED.	DESIGN RELIABILITY	- -	1 ADD THIS POINT AS REQUIRED TO S&A REDESIGN. 2 STUDY IN PROGRESS.
016 ADDF	10-G GAG	TEST SHOULD BE CONDUCTED TO DETERMINE FI THE 10-G GAG COULD MOVE TO A POSITION WHICH WILL BLOCK THE SLIDER IF A SECOND IMPACT IS SEEN IN A DIRECTION OPPOSITE TO THAT OF INITIAL IMPACT.	DESIGN TEST RELIABILITY	(1) CONDUCT TEST.	
017 ADDF	BFD'S	BFD CAN BE INSTALLED IN FUZE WITHOUT FULL THREAD ENGAGEMENT. DESIGN CHANGE WHICH MAKES BFD'S EASIER TO INSTALL AND REMOVE IS DESIRABLE.	DESIGN RELIABILITY	- -	SAME AS CONTROL NO. 009

TABLE VI. CRITIQUE SUMMARY, AF DESIGN AND SAFETY REVIEW (CONTINUED)

WORKSHEET CONTROL NO.	FUZE COMPONENT MODULE ETC.	COMMENTS ON PROBLEM	PROBLEM EFFECTS	(1) ADDF ACTION ITEM (2) ACTION TAKEN	(1) CONTRACTOR ACTION ITEM (2) ACTION TAKEN 31 DECEMBER
018 (ADDF)	BFG LANYARD ATTACHMENT	PRESENT ATTACHMENT METHOD SHOULD BE REPLACED BY STANDARD METHOD.	DESIGN HANDLING	ADVISE CONTRACTOR OF STANDARD SELECTION.	(2) WILL BE ACCOMPLISHED WHEN STANDARD IS DETERMINED.
019 (TFWC)	TES	TESTS SHOULD BE CONDUCTED TO VERIFY THE CONTRACTOR'S DATA.	DESIGN TEST	(1) CONDUCT TESTS TO VERIFY PROPER FUNCTIONING OF TES ON VARIOUS TARGETS.	- -
020 (ADDF)	S7	IF SHORTED IN ARMING POSITION, S7 WILL BYPASS TES CKT. FUNCTION AND ARM FUZE.	DESIGN SAFETY	- -	(1) INVESTIGATE SELF-CHECK FEATURES AND REPORT TO PROJECT OFFICER. INCORPORATE CHANGE IN SERVICE TEST MODES, IF POSSIBLE. (2) STUDIES PRESENTED 8 DEC. INCORPORATED INTO 105-UNIT BUILD.
021 (ADDF)	SAFE-PIN BALL SEAL	JAMMING OF BALL IN SEAL ASSEMBLY ALLOWS FUZE TO LEAK.	DESIGN SAFETY RELIABILITY	- -	(1) INVESTIGATE REDESIGN AND MAKE RECOMMENDATION BY 1 DEC. 1969. IF FEASIBLE, INCORPORATE CHANGES ON SERVICE-TEST MODELS. (2) STUDIES COMPLETE. DESIGN PRESENTED 8 DEC. INCORPORATED INTO 105-UNIT BUILD.
022 (ADDF)	TP14 VR	IF TP14 IS GROUNDED DURING CHECK-OUT OF P.C. BD. #4, THE VOLTAGE REGULATOR WILL DEGRADE.	DESIGN RELIABILITY	- -	(1) CLARIFY TEST PROCEDURES. (2) CAUTION NOTE ADDED TO DRAWING. SUBSEQUENT TEST SHOWED NO PROBLEM IN P009 CKT.
023 (ADDF)	S6, S7, PISTON ACTUATORS 1 THROUGH 5	IMPACT SENSITIVITY OF COMPONENTS CREATES SAFETY AND RELIABILITY PROBLEMS.	DESIGN SAFETY RELIABILITY	- -	(1) VERIFY ADEQUACY OF VENDOR CHANGES BEFORE INCORPORATION IN SERVICE-TEST MODELS. SUBMIT TEST DATA TO PROJECT OFFICER BY 22 DEC. 1969. (2) DESIGN CHANGES WILL BE IN FUZE BUILD. TEST SCHEDULED FOR 10 JAN. DUE TO LATE DELIVERY OF COMPONENTS.
024 (ADDF)	EVENT TIME	EVENT CIRCUIT SHOULD BE REVISED SO INDICATED AND ACTUAL EVENT TIMES AGREE WITH RESPECT TO START OF TIMING DELAY WITH BATTERY INITIATION.	DESIGN	- -	(1) INCORPORATE REVISION OF EVENT CIRCUIT IN SERVICE-TEST-MODEL BUILD. INFORM ADTC OF ASSEMBLY TIME-TOLERANCE CHANGES NECESSARY TO ACCOMPLISH REVISION. (2) E.O. WRITTEN. DATA NOT COMPLETE FOR TOLERANCE RECOMMENDATION.
025 (ADDF)	FUZE	ELECTRONICS SECTION SHOULD BE MADE IMMUNE TO PRESENCE OF MOISTURE.	DESIGN SAFETY RELIABILITY	- -	(1) CONTINUE INVESTIGATION OF REPLACEMENT SEALANT MATERIAL. (2) INVESTIGATION INCOMPLETE. SEALANT PROPOSED FOR USE IN SERVICE-TEST-MODEL BUILD IS IN T&H EVALUATION ON BARE, EXPOSED UNIT.

TABLE VI. CRITIQUE SUMMARY, AF DESIGN AND SAFETY REVIEW (CONCLUDED)

WORKSHEET CONTROL NO.	FUZE COMPONENT MODULE ETC.	COMMENTS ON PROBLEM	PROBLEM EFFECTS	(1) ADDF ACTION ITEM (2) ACTION TAKEN	(1) CONTRACTOR ACTION ITEM (2) ACTION TAKEN 31 DECEMBER
026 (ADDS)	LEADS FROM CENTER POST OF S2 AND S3	LONG JUMPERS GIVE RISE TO POSSIBLE INSULATION BREAKDOWN CAUSING A SHORT.	DESIGN SAFETY RELIABILITY	- -	(1) PROVIDE SHORTER JUMPERS TO MINIMIZE THE NUMBER OF CONTACTS JUMPERS ARE EXPOSED TO. (2) STUDY NOT COMPLETED FOR 105-UNIT BUILD.
027 (AFIAS-S	15-HOUR SETTING	SETTING IN PRESENT POSITION WILL BE MISREAD AS 150 HOURS.	DESIGN SAFETY HANDLING	- -	(1) CHANGE 15 TO XV WITH SETTING INSTRUCTIONS ON FACE OF FACE (2) E.O. HAS BEEN WRITTEN FOR 105-FUZE BUILD.
028 (ADDS) (AFIAS-S)	SAFE SETTING	SAFE SETTING AVAILABLE ONLY ON ONE TIME-SETTING DIAL. EITHER SHOULD SAFE THE FUZE.	DESIGN SAFETY HANDLING	- -	(1) CHANGE TO HAVE SECOND DIAL CONTAIN SAFE SETTING. (2) E.O. BEING WRITTEN FOR INCORPORATION IN 105-FUZE BUILD

GLOSSARY OF ACRONYMS USED IN TABLE

TES - TERMINAL ENVIRONMENT SENSOR
ILAT - IN-LINE ARMING TIMER
PIT - PRE-IMPACT TIMER
BUT - BACKUP TIMER
BFD = BATTERY FIRING DEVICE
PA = PISTON ACTUATOR
P.C. = PRINTED CIRCUIT

TABLE VII. TEST RESULTS OF 24 HONEYWELL TEST MODEL FUZES

TEST GROUP		PIT	ILAT	DELAY TIME		BUT	FAILURE ANALYSIS
				SET	ACTUAL *		
ST-1 LOT ACCEPTANCE	-1	2.5	22' 3"	23	23:43	NT	BAD PWBD #5
	-2	2.6	NR	24	24:07	216:14	
	-3	2.4	21' 31"	21	<24:37	234:27	
	-4	2.2	22' 5"	21	<23:26	210:54	
ST-2 HIGH TEMPERATURE	-1	2.8	35' 15"	24	26:30	NT	MISWIRED PA-1 LEAD
	-2	2.1	18' 25"	24	27:12	235:49	
	-3	OK	NR	1	NR	NT	DEFORMED PC BOARD; S6 FIRED EARLY; UNIT DUDDED.
	-4	2.3	28' 11"	20	0.28	NT	DEFORMED PC BOARD
ST-3 LOW TEMPERATURE	-1	2.6	23' 12"	20	19:54	NT	DID NOT ARM
	-2	2.5	21' 40"	1	NR	NT	MISWIRED (TEMP. FIX)
	-3	2.7	23' 23"	1	1:04	NT	SOLDER BRIDGE
	-4	2.5	32' 20"	192	190:33	225:21	BAD PWBD
ST-4 WATERPROOFNESS	-1	2.2	21' 59"	192	190±6	220	SEAL LEAKAGE
	-2	INOPER-ATIVE	21' 55"	163	NT	NT	SEAL LEAKAGE
	-3	2.3	21' 57"	72	72:20	220:17	SEAL LEAKAGE
	-4	2.2	17' 41"	24	NR	239:13	SEAL LEAKAGE
ST-5 ROUGH HANDLING	-1	NR	20' 47"	16	15:50	NT	FUZE DUDDED AFTER BFD SELF INITIATED ON MISSILE PULLOFF
	-2	2.3	21' 38"	1	1:01	NT	S6 OPEN BRIDGE WIRE
	-3	2.5	18' 39"	20	20:00	NT	OPEN DIODE IN PA-5
	-4	2.3	22' 6"	90	<91:00	NT	OPEN DIODES IN NT OUTPUT
ST-6 LOT ACCEPTANCE	-1	2.2	21' 50"	22	<25:00	NT	OPEN SOLDER PATH
	-2	2.5	22' 11"	22	21:53	223:36	———
	-3	2.2	21' 46"	22	22:25	226:51	———
	-4	2.4	24' 33"	20	20:00	232:41	———

NR – NOT RECORDED

NT – NOT TESTED

* – EVENT TIME AS TRIGGERED BY NT CIRCUIT IN SOME CASES WAS BENCH TEST AFTER FUZE TEAR DOWN FOR F&A.

TABLE VIII. FMU-63/B F&A SUMMARY - SPONSOR TEST OF 81 SERVICE TEST MODELS

LOW DRAG AND SLED TEST

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
16	63-42371	Capacitor C90 Shorted
20	63-42369	Accidentally Dropped Safe (Conjecture)
21	63-42379	Accidentally Dropped Safe (Conjecture)
25	63-42365	Zener Diode (CR94) Open In Sled Test
31	63-42375	Deformed BFD Firing Pin Spring
32	63-42380	Orange Wire (B^+) Shorted to Case (Ground)
34	63-42372	Squib Switch Bridge (S7) Open
66	63-43301	Zener Diode (CR14) Open
46	63-43338	Open Piston Actuator Bridge (PA-2)

HIGH DRAG ARM FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
3	63-43333	Marginal TES Design
9	63-43307	Marginal TES Design
13	63-42359	Marginal TES Design
14	63-43308	Marginal TES Design
26	63-43311	Marginal TES Design
28	63-43313	Marginal TES Design
30	63-42367	Marginal TES Design
30	63-43335	Marginal Energy For Gag Retainer
41	63-43315	Marginal TES Design
44	63-43316	Marginal TES Design

TABLE VIII. FMU-63/B F&A SUMMARY - SPONSOR TEST (Continued)

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
57	63-42373	Impact Switch S5 Potted
64	63-43320	Marginal TES Design
73	63-43302	Marginal TES Design
74	63-43303	Marginal TES Design
75	63-43323	Marginal TES Design
76	63-42360	Impact Switch S5 Potted
77	63-42374	Marginal TES Design
78	63-43324	Marginal TES Design

FAILURE TO EVENT

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
29	63-42370	Piston Actuator Bridge (PA-4) Open

EARLY EVENT FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
31	63-42378	TP3 Not Grounded
33	63-42377	No "O" Ring on Selector Switch (S2)

LATE EVENT FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
48	63-42366	Unstable Coulometer

BACKUP TIMER FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
61	63-43300	Not Verified

TABLE VIII. FMU-63/B F&A SUMMARY - SPONSOR TEST (Continued)

ANTI-DISTURBANCE FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
47	63-43325	Phenolic on Ball of A.D. Switch

ACCIDENTAL RELEASE FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
49	63-42361	Lanyard Snagged at Impact
50	63-43317	Lanyard Snagged at Impact
51	63-43318	Lanyard Snagged at Impact
54	63-43337	Lanyard Snagged at Impact

BATTERY STATE INDICATOR FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
22	63-43310	Safe Pin Guide Slipped
26	63-43312	Safe Pin Guide Slipped
34	63-43327	Open Piston Actuator Bridge (PA-1)
42	63-43328	Safe Pin Guide Slipped
49	63-43326	Connection Not Soldered
58	63-43319	Marginal Energy for BSI
62	63-42368	Open Piston Actuator Bridge (PA-1)
73	63-43322	Safe Pin Guide Slipped

INTERRUPTER PAINT FAILURES

FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
3	63-43306	Improper Paint Method
19	63-43309	Improper Paint Method
47	63-42381	Improper Paint Method

TABLE VIII. FMU-63/B F&A SUMMARY - SPONSOR TEST (Concluded)

FORTY-FOOT DROP FAILURE		
FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
55	63-43334	Marginal Energy For Gag Retainer
BATTERY RELATED FAILURES		
FUZE NO.	FAR NO.	FAILURE ANALYSIS RESULTS
11	63-43304	BFD Firing Pin Tip is Too Long
61	63-42356	Misconception of Fuze Operation On Part of Test Personnel
ELECTRICAL BFD FAILURES		
BFD NO.	FAR NO.	FAILURE ANALYSIS RESULTS
15	63-42376	Potting On Ground Contact

A formal Design Review was conducted at Hopkins during the week of 8 February 1971. The review covered the design shown schematically on X68F5638 Revision J, and mechanically on X68F5639 Revision G. A group of 23 worksheets resulted from this review, as identified in Table IX. Seventeen of the sheets concerned documentation classifications or minor component revisions. The Closure Lock, Out-of-Line Safety, TES, Accidental Release, Water Seal, and Packaging items were the remaining identified problem areas. Contractor action on these problem areas was accomplished as rapidly as possible.

An investigation to sensitize the omnidirectional switch (X67A5365) to less than 100 g's was conducted. The results of this investigation are summarized in Appendix I.

Significant changes that were contemplated for the 338 prototypes as a result of the tests conducted on the 105 service test models is summarized in Table X.

The development and evaluation of the fuze assembly, components, and subassemblies for the FMU-63/B fuze continued throughout the life of the program. A summary of all tests conducted during the program to qualify and define the most pertinent components and subassemblies of the FMU-63/B fuze is presented in Appendix II. This summary also includes test results and recommendations for improving the fuze assembly, component, or subassembly design or assembly process.

A summary of the FMU-63/B fuze compliance to the design requirements and objectives specified in the Fuze Safety Criteria is presented in Appendix III.

The 338 live and inert fuzes fabricated in fulfillment of contract line items 9 and 10 were delivered as designated in Table XI. The fuzes were of the

TABLE IX. LIST OF WORKSHEET RESULTING FROM FEBRUARY 1971 DESIGN MEETING

WORKSHEET CONTROL NO.	PROBLEM AND COMMENTS	AFFECTS	DLGF ACTION	CONTRACTOR ACTION
01 DLGF	IMPROVE CLOSURE LOCK. DESIGN MUST CAUSE 180° ROTATION. ACCEPTABLE DESIGN MUST BE IN 338 BUILD.	DESIGN TEST	NONE.	HAVE MODEL AVAILABLE 15 MARCH FOR DLGF ACCEPTANCE. INCORPORATE INTO 338 BUILD.
02 DLGF	FUZE FAILED OUT-OF-LINE SAFETY TEST. MIL-STD-331 REQUIREMENT MUST BE MET.	DESIGN TEST SAFETY	CONDUCT CONFIRMING TEST DURING QUAL TEST.	DEMONSTRATE ADEQUATE DESIGN BEFORE ASSEMBLY OF PROTOTYPE FUZES. INCORPORATE INTO 338 BUILD AS INTERIM. SUPPLY FINAL FIX ON 12 ITEMS.
03 DLGF	TES DOES NOT PROVIDE "GO" SIGNAL FOR HIGH DRAG BOMBS. LOWER G LEVEL SWITCH NEEDS TO BE EMPLOYED.	DESIGN TEST RELIABILITY	CONDUCT FIELD TESTS OF PROPOSED DESIGN CHANGE DURING MARCH (FIXED WING TEST AND LAB TEST).	ASSEMBLE TES RECORDERS AND SUPPLY TO DLGF FOR FLIGHT TEST. INCORPORATE SENSITIVE SWITCHES INTO 338 BUILD.
04 NAVEODFAC	EOD FEATURE: DELAY NOT FIRM.	DESIGN SAFETY	NOTIFY CONTRACTOR OF REQUIREMENT AFTER EOD TEST.	MODIFY DRAWINGS IF DLGF REQUESTS CHANGE.
05 RADC	RELIABILITY PREDICTION: PUBLISHED INFO IS OPTIMISTICALLY HIGH IN THAT IT CONTAINS ONLY "AS DELIVERED" DATA.	TECH DATA	NONE	UPDATE PREDICTION TO CLARIFY THAT STORAGE, IMPACT, ETC., EFFECTS ARE NOT INCLUDED.
06 DLGS	LLAD: NOMENCLATURE MISSING.	HANDLING	DLGF WILL NOTIFY CONTRACTOR AFTER IDENTIFICATION HAS BEEN ESTABLISHED.	NONE.
07 RADC DLGS NAVEODFAC	FUZE FAILED ACCIDENTAL RELEASE TEST. MIL-STD-331 REQUIREMENTS FOR TEST 205 AND 206 MUST BE MET.	DESIGN TEST SAFETY	POSSIBLE EVALUATION DURING FUZE QUAL TEST.	SUBMIT REDESIGN CONCEPT FOR AF APPROVAL. BUILD AND TEST MODELS. SUPPLY PRESENT BFD FOR PROTOTYPE BUILD. SUPPLY MODIFIED VERSION ONLY IF AF APPROVES.
08 DLGF	WORKMANSHIP INADEQUATE.	RELIABILITY	NONE.	LOT SAMPLE TESTING MUST BE COMPLETED AND RESULTS SUBMITTED TO AF FOR APPROVAL OF ASSEMBLY OF ITEMS DELIVERABLE TO AF EVAL.
09 RADC	SPECIFICATIONS INADEQUATE. COMPONENT PARTS ARE USED IN MANNER NOT CONTROLLED IN COMPONENT CONTROL DRAWING.	DESIGN RELIABILITY	NONE.	REVIEW ELECTRONIC SPECS AND MODIFY AS REQUIRED.
10 DLGF DLGS	EOD INFORMATION NOT CLEAR.	SAFETY	NONE.	REWRITE INFORMATION ON BSI TO CLARIFY FUZE STATUS IF SAFING PIN CANNOT BE INSERTED FULLY.
11 TGWB	INADEQUATE TEST EQUIPMENT FOR FIELD EVALUATION IF HELICOPTER DROPS ARE REQUIRED.	TEST	MODIFY TEST PLAN TO EMPLOY FIXED WING TEST ONLY.	NONE.
12 DLGF	INADEQUATE WATER-SEAL. FUZE FAILED 50 FOOT WATER REQUIREMENT WHEN USING BALL SEAL ALONE.	DESIGN TEST	REQUEST PROPOSAL FROM CONTRACTOR.	SUBMIT REDESIGN CONCEPTS FOR DLGF APPROVAL.
13 MMECB	GATHER DATA ON AGING OF FUZE COMPONENTS. DESIRABLE TO GET FUZE STORAGE CAPABILITY DATA EARLY IN PRODUCTION PHASES.	RELIABILITY	CONTACT PPZ WITH OBJECTIVE OF INITIATING SUCH A PROGRAM.	NONE.
14 USAF TAWC	INADEQUATE USER DATA ON SAFING PIN. CLARIFY DEFINITION AS TO WHEN SAFING PIN IS FULLY INSERTED.	DESIGN SAFETY HANDLING	NONE.	REWRITE INFORMATION TO CLARIFY SAFING PIN USAGE (SEE WORKSHEET 10).
15 USAF TAWC	NONSTANDARD SAFING PIN. PINS SHOULD BE DESIGNED TO PERMIT USE IN ANY RELATED FUZE.	DESIGN HANDLING	INVESTIGATE REQUIREMENT AND DIRECT CONTRACTOR IF NECESSARY.	NONE.
16 USAF TAWC	IMPROVE SAFE HANDLING. REMOVE SAFETY CLIP ONLY AFTER RUNNING LANYARD THROUGH PLUMBING.	TECH DATA- SAFETY HANDLING	NONE.	REVISE WRITEUP TO REFLECT CHANGE IN PROCEDURES.
17 DLGF	CONFLICT OF PACKAGING REQUIREMENTS: CONTRACT REQUIRES PACKAGE OTHER THAN THAT DESIRED BY DLGF FOR END ITEM.	DESIGN TEST	INFORM CONTRACTOR BY MAR 15 OF PACKAGE REQUIREMENT. CONDUCT PACKAGE EVALUATION.	PROVIDE NEW PACKAGE WITH 328 FUZES DELIVERED TO AF.
18 DLGF	INADEQUATE HITCH PIN GROOVE.	DESIGN HANDLING	NONE.	ADD HITCH PIN GROOVE SIMILAR TO THAT OF FMU-61/B. MAKE CHANGE IN 338 HARDWARE.
19 TGWB	IMPROPER ATTACHMENT OF CORD ON SAFING PIN. PIN CANNOT BE PULLED REMOTELY WITH CORD.	DESIGN HANDLING	NONE.	SUBMIT MODIFICATION TO DLGF FOR APPROVAL PRIOR TO DRAWING CHANGE. MAKE CHANGE IN 338 HARDWARE.
20 TGWB	CANNOT INSERT SAFING PIN PRIOR TO FIN REMOVAL WHEN DOWNLOADING HIGH-DRAG TAIL FINS.	DESIGN TECH- DATA HANDLING	NONE.	REWRITE DOCUMENTATION TO REFLECT THAT SAFING PIN MAY BE INSTALLED AFTER TAIL FIN REMOVAL.
21 TGWB	INTERRUPTER SPRING NOT REQUIRED. SEAR HEADER DOES OUT-OF-LINE RETENTION DURING IMPACT.	DESIGN	NONE.	NONE. (SPRING WILL REMAIN TO REDUCE CHATTER OF INTERRUPTER DURING VIBRATION.)
22 DLGF	HUMAN FACTORS IMPROVEMENT DESIRABLE: 1) SIMPLIFY SETTINGS. 2) SAFING PIN REDESIGN. 3) FACE DECAL REMOVAL.	DESIGN TEST HUMAN FACTOR	REQUEST PROPOSAL FOR LATER DESIGN MODIFICATION IF DESIRED.	RESPOND TO AF RFP IF REQUESTED.
23 DLGF	BOOSTER SHIPPED IN PLACE; NOT CONSISTANT WITH OTHER FUZE PACKAGING.	DESIGN TECH- DATA HANDLING	DIRECTED CONTRACTOR TO PACKAGE BOOSTER AS WITH FMU-72/B.	MODIFY DRAWINGS TO SHOW BOOSTER AS REMOTELY PACKAGED ITEM.

TABLE X. CHANGES MADE TO 338 PROTOTYPES AS A RESULT OF TESTING 105 SERVICE TEST MODELS

DESCRIPTION	CHANGE
S&A Assembly	New design contains detented gag (which was tested in OEXM 22454) and relief holes for detonator out-of-line.
Schematic	Revised settings to eliminate XV on S2. Revised settings to eliminate "10" "12" on S3. Revised LVSD circuit for High Impedance Battery. Revised R48/C7 connection to improve CR16 gate protection and increase voltage to firing circuit. Relocate SB2 and SB5 to better protect S7 and S6. Increase C1 and C3 capacities to improve PA-1 and PA-2 firing. Add CR102 to minimize probability of firing PA-5 in dudding function.
Printed Wiring Boards	Improve processing and assembly capabilities. Incorporate changes per schematic circuit revisions. Provide proper mounting of S2 and S3 referenced to electronic housing.
BFD Assembly	Long stroke slider for missile pull-off protection. Improved design to eliminate accidental release lanyard snag initiation is in evaluation.
Firing Pin Clip	New fabrication technique permitted.
Firing Pin	Shorter tip to prevent battery shim puncture.
Closure Lock	Cam design replaces leaf spring.
Interrupter	Add inspection and firing pin holes. Add X-ray inspection. Add improved painting process.

TABLE X. CHANGES MADE TO 338 PROTOTYPES AS A RESULT OF TESTING 105 SERVICE TEST MODELS (CONCLUDED)

DESCRIPTION	CHANGE
Safing Pin	Loop is closed. Flag tie-off improved.
Retainer Pin	Deeper hole to accept follower.
Ball Follower	Strengthen collar and improve alignment.
Assembly Container	Change metal finish to cadmium. Added screw holes for spacer. Provide indexing notch to electronic housing. Reworked for improved welds and solder.
Clip, Booster	Single finger replaces double.
Assembly, Elect. Housing	Guide eliminated in new seal design. Improve potting.
Assembly, Fuze	Replaced foam potting with epoxy. Improved leak check equipment.
Switch, Explosive	Improved shock resistance. 100 percent X-ray sort.
Diode, Zener	Improved shock resistance (new vendor). 100 percent functional screen.
Timer, E-Cell	Improved tolerance (new vendor).
Switch, Selector	Improved pottability (new vendor).
Switch, Inertial	Lower nominal value of Low-G. Improved sealing control.

TABLE XI. BUILD CONFIGURATION – FMU-63/B PROTOTYPE FUZES

LINE ITEM	QUANTITY	TENTATIVE USE *	TEST BY	EST. SHIP DATE	EXPL. BOOSTER	LEAD CUP	M55 DETONATOR	EOD	TES	S&A	CONTAINER	GAG STOP	ELECTR	AD	AF CONFIG.
9b	10	LOT ACCEPT	(H)	25 JUN	INERT	NONE	LIVE	STD	95g	STD	INTERIM	YES	STD	INACTIVE	A
9a	32	QUAL CONFORM	DLJF	6 AUG		NONE						NONE	31 MAY	1 ACTIVE 31 INACTIVE	B A
	75	ENVIRON GROUP III	DLJF	27 AUG		NONE								18 ACTIVE 57 INACTIVE	B A
	30	SEQ ENVIRON GROUP IV	DLJF	24 SEP	INERT	LIVE								INACTIVE	C
	48	FLIGHT GROUP V	DLJF	15 OCT	DLJF									INACTIVE	C
	53 (a)	SAFETY GROUP I	DLJF	29 OCT	INERT					STD	INTERIM		31 MAY	ACTIVE	D
	12	STAT DET GROUP II	DLJF	8 OCT	DLJF					SPECIAL	NEW		INACTIVE	INACTIVE	E
9c	10	EOD	I	5 NOV	DLJF	LIVE	LIVE			STD	INTERIM ⊠		15 JUN	ACTIVE	D
9d	5 5	EOD FLIGHT	I DLJF	5 NOV 29 OCT	DLJF DLJF	NONE LIVE	NONE LIVE				⊠		15 JUN 15 JUN	ACTIVE INACTIVE	F C
9e	2 8	HERO FLIGHT	DLJF DLJF	5 NOV 5 NOV	DLJF DLJF	NONE LIVE	NONE LIVE			STD	⊠		15 JUN 15 JUN	ACTIVE ACTIVE	F D
10	5	HAZARD	(H)	29 OCT	NONE					SPECIAL			INACTIVE	INACTIVE	G
	12	HAZARD	(H)	12 NOV		LIVE	LIVE			STD			15 JUN	ACTIVE	H
	19	FLIGHT	DLJF	12 NOV		LIVE	LIVE			STD			15 JUN	6 ACTIVE 13 INACTIVE	D C
	12	LOT SAMPLE	(H)	VARIES	NONE	VARIES	LIVE	STD	95g	STD	INTERIM	NONE	15 JUN	ACTIVE	VARIES

* REF PRELIMINARY CEI SPEC XCP68F6675

(H) - HONEYWELL HOPKINS

DLJF - EGLIN

I - DLJF BY INDIANHEAD EOD

(a) SHIP 12 IMPROVED BFD's 15 OCTOBER

CONFIGURATION PLANNED FOR COMPLETION OF 338 UNITS

QUANTITY TO BE BUILT	CONFIGURATION	FUZE SERIAL NUMBER BLOCK
102	A	[illegible] THRU 0299
20	B	0300 THRU 0399
99	C	0400 THRU 0499
81	D	0500 THRU 0599
12	E	0600 THRU 0699
7	F	0700 THRU 0799
5	G	0800 THRU 0899
12	H	0900 THRU 0999
338 TOTAL		

⊠ CONTAINERS NOT CRIMPED OR SEALED

15 EOD CONFIGURATION F AND CONFIGURATION D

2 DLJF CONFIGURATION F

design described in the Introduction of this report and in the FMU-63/B fuze schematic diagram (Figure 4).

An electrical BFD to adapt the FMU-63/B fuze to the USN electrical initiation system was designed, fabricated, and successfully tested. The electrically initiated BFD is illustrated in Figure 5.

The FMU-63/B fuze was designed to operate in the following manner.

<u>Operational Sequence</u> (Figure 6)

On release from the aircraft, activation of the battery is initiated by cocking and firing the battery firing device. This requires a pull on the lanyard cable of approximately 35 pounds, which shears a wire in the BFD assembly, cocks, and releases a spring-loaded percussion firing pin which activates the liquid ammonia battery.

The liquid ammonia reserve battery has a rapid voltage rise, attaining peak value in one second or less. The nominal voltage is 9.3 vdc, with an initial rise peak as high as 13 vdc.

As the voltage rises, power is applied to the power sequencer circuit, which initiates the in-line arming timer and pre-impact timer; it also enables the terminal environment sensor (TES), self-check circuit, and the arm and fire enable.

The pre-impact timer (PIT) and dial shutter (DS) circuit are the first to function. The PIT is a fixed timer, nominally set to time out 2.6 seconds after battery initiation. Its purpose is to delay the enable of the TES until 2.6 seconds of undisturbed (low-shock level) velocity of the bomb has elapsed. A disturbance in excess of 90 G's during the 2.6-second period will reset the PIT and commence a new 2.1-second time-out period. This feature prevents the TES from functioning if initial impact occurs early. Once the 2.6-second free-flight period has been attained, a signal from

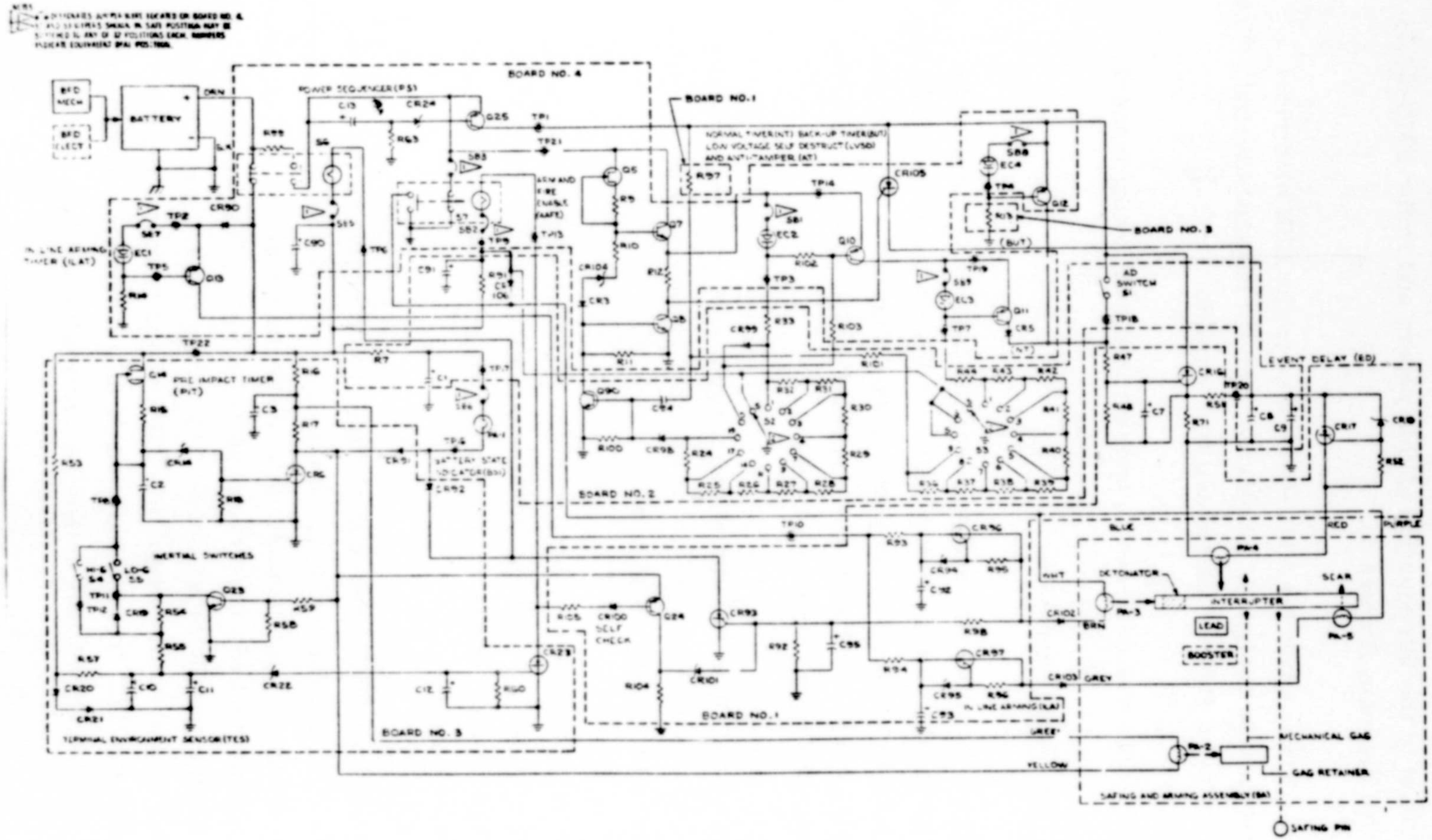

Figure 4. FMU-63/B Fuze Electrical Schematic

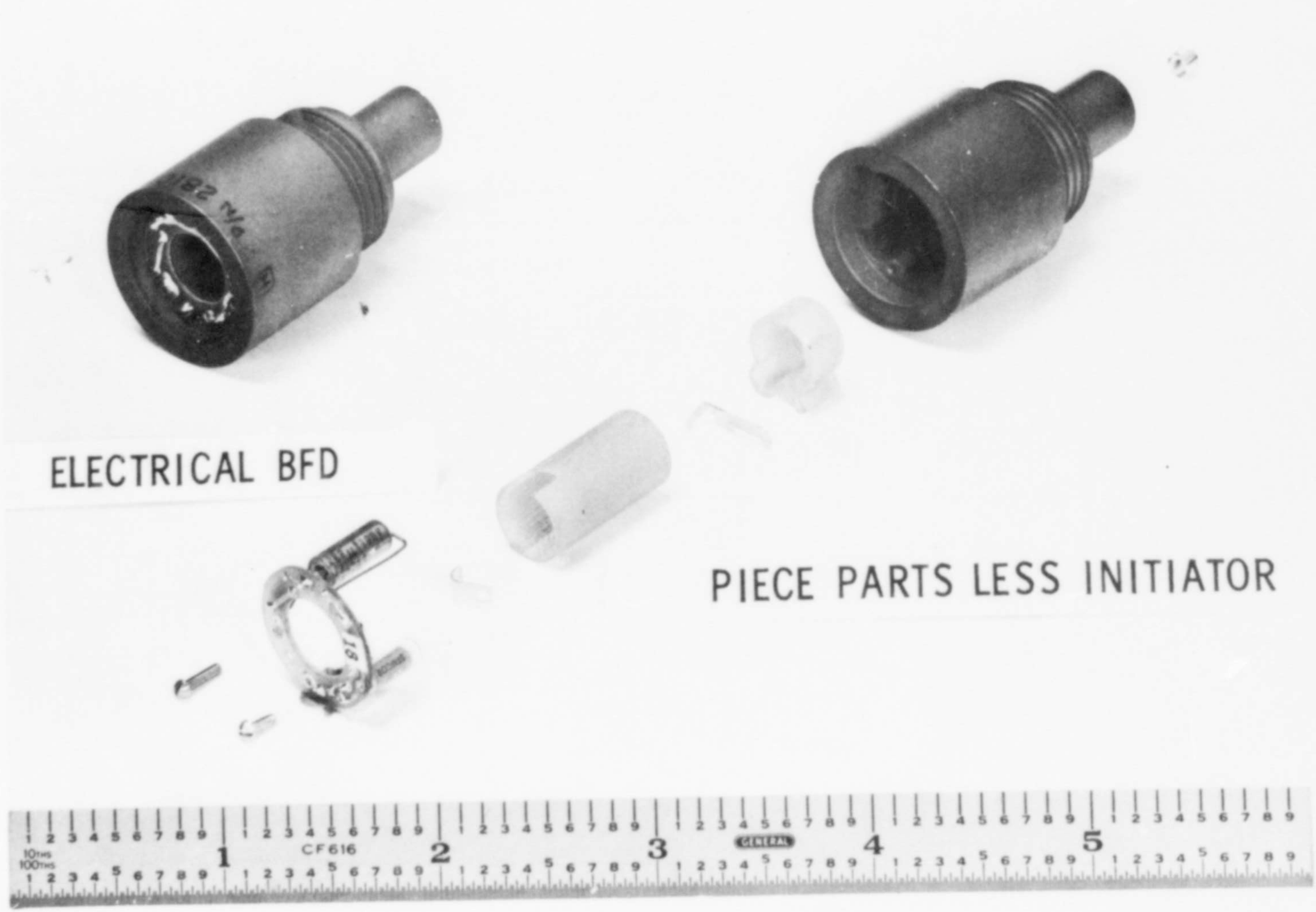

Figure 5. Electrical BFD

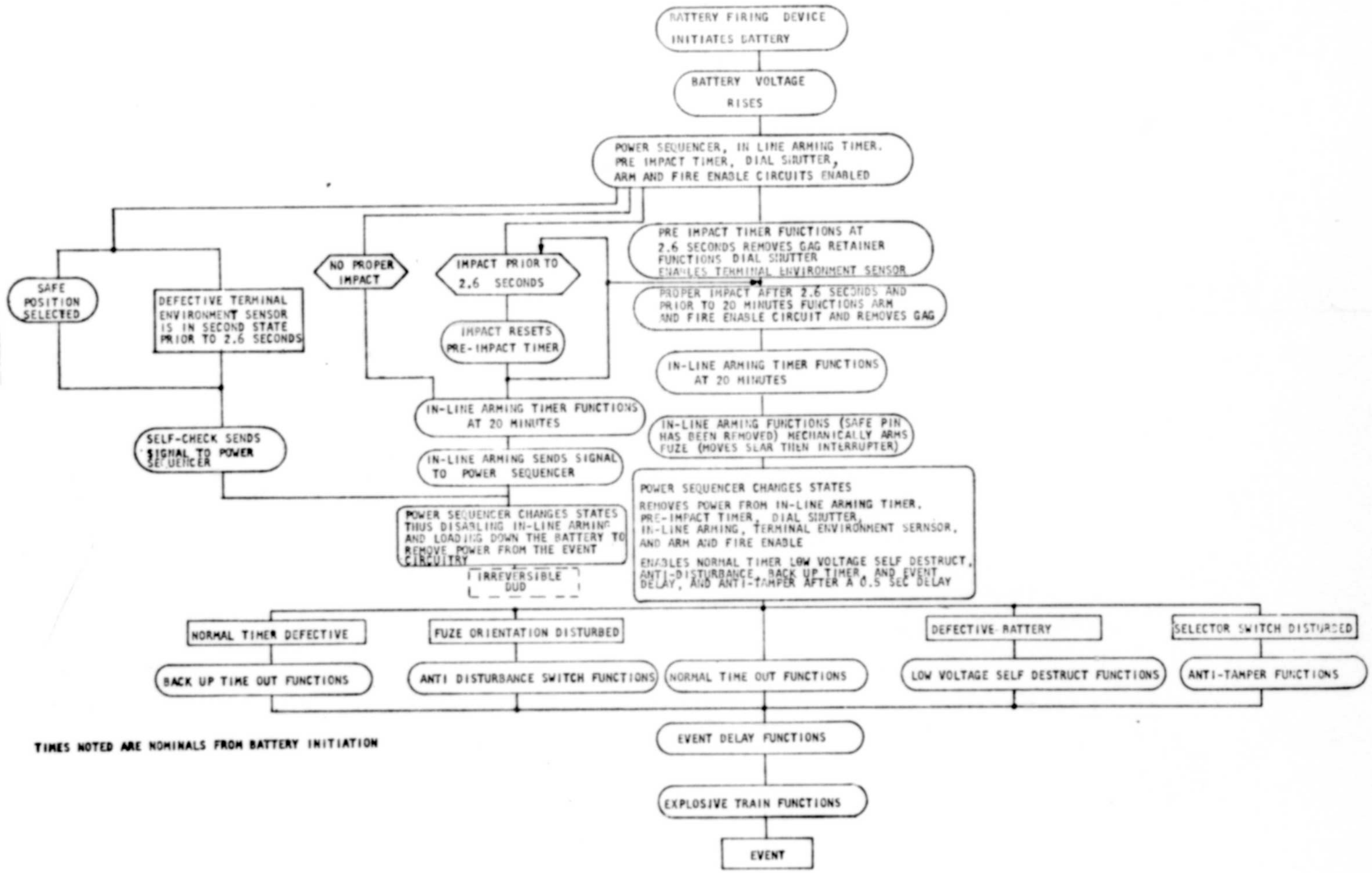

Figure 6. FMU-63/B Operational Sequence Flow Chart

the PIT will enable the TES and fire the gag retainer piston actuator. This removes the retainer from the mechanical gag, which normally locks the detonator out-of-line. The dial shutter functions when the PIT times out. The dial shutter mechanism contains a piston actuator which moves the shutter across the selector switch windows and covers the access hole for the safe pin. The dial shutter is locked in the closed position by the actuator locking piston. The dial shutter is also designed to function if the fuze duds.

When the PIT, reset circuits, and dial shutter functions have been completed, the in-line arming timer (ILAT) will be activated and the impact sensors, TES, and arm and fire enable circuits will be enabled. The system will then wait for an impact of greater than 190 fps velocity change with a single pulse greater than 90 G's.

When impact occurs, the impact sensors (omni-directional inertial switches) close and the mechanical gag on the interrupter is moved out of the interrupter-interference position. Closing the inertial switches for the proper time duration provides the logic signal the TES needs to fire the arm and fire enable which will then enable the in-line arming. The system will remain in this condition until the in-line arming timer (ILAT) times out (approximately 20 minutes after release from the aircraft).

When the ILAT times out, it sends a signal to the in-line arming circuit. If the in-line arming has been enabled by the arm and fire enable, it will then:

(a) Remove the sear (the last mechanical lock on the interrupter)

(b) Move the interrupter in-line

(c) Function the power sequencer (PS).

When the power sequencer is activated, power is removed from the ILAT, PIT, TES, self-check, arm and fire enable, in-line arming, and dial

shutter circuits and is applied to the firing circuit which contains the normal timer (NT), back up timer (BUT), antitamper (AT), antidisturbance (AD), low-voltage self destruct (LVSD), and event delay circuits. A signal from any of the event sources will trigger the event function. The event functions are triggered in the following manner:

(a) Normal Timer (NT) - The decade and unit timers function in sequence. When the coulometric-time-base components have transferred all of their plating material, the increased resistance of the component causes a transistor to switch on, thereby providing voltage to the next link. When the unit timer has been depleted, its transistor delivers the voltage to the firing SCR which triggers the event delay.

(b) Antitamper (AT) - This feature causes an event signal to be delivered to the LVSD SCR if either of the originally selected dial settings is tampered with after arming. The switches, being non-shorting types, cause a pulse signal to be generated in the AT circuit, which will gate on a transistor which, in turn, energizes the LVSD SCR.

(c) Antidisturbance (AD) - This feature utilizes a detented ball switch which is sensitive to rotational disturbance of the fuze. It is a normally open switch regardless of attitude, but will deliver a momentary closure when disturbed. This feature, enabled only after completion of arming, gates the firing SCR and event delay when the closure (fuze or fuze and bomb disturbance) occurs.

(d) Backup Timer (BUT) - This is a coulometric, fixed-time unit (10 days nominal) which is energized after power sequence switching. It is basically a clean-up feature which will event the fuze through the normal-firing SCR if it is capable of being evented.

(e) Low-Voltage Self-Destruct (LVSD) - This feature is included to provide an event signal in case the internal power supply is degenerating prior to normal event time. It is designed to function slightly above the minimum voltage required for the final eventing sequence, thereby eliminating the possibility of a dud caused by a failure in the power supply.

SECTION IV

RELIABILITY/SAFETY PROGRAM

A reliability/safety program was conducted concurrently with the design and development of the FMU-63/B Long Delay Bomb Fuze to assure achievement of the reliability figures specified in paragraph 3.10 of Research and Development Exhibit Number ATW-67-20D. A reliability program plan, dated May 1969, was submitted and approved by the Air Force. A summary of results against the tasks outlined in the program plan follow:

A. MATHEMATICAL MODELS

A mathematical model of the fuze was constructed in accordance with paragraph 2.3 of the RADC Reliability Notebook - Volume I. The mathematical model description is contained in the FMU-63/B fuze reliability prediction report.

B. SAFETY ANALYSIS

A comprehensive safety analysis of the FMU-63/B fuze was performed to identify all critical characteristics and critical defects that could reasonably result in a hazard. Seven hazards were defined that could occur during the life of the fuze. A hazard path diagram (analogous to fault tree diagrams) was constructed for each hazard. These diagrams represent the combinations of accidents, fuze defects, abnormal environments, and normal occurrences that could lead to a hazard. Probabilities were determined for each of the fuze defects or conditions. To summarize the safety analysis, it was concluded that:

- The fuze can be safely stored, transported, and loaded into bombs, as long as the fuze is not subjected to fire.
- A significant probability exists that an event can occur at the preset time when trying to safe jettison. This problem exists because of a potentially defective aircraft bombing system or an accidental arming of the aircraft bombing system by the pilot. The probability

of this hazard occurring is estimated at 2.0×10^{-2}.

- There also exists a potential problem that is related to an event during a broach or ricochet due to a defective In-Line Arming Timer. The probability of this hazard is estimated at 1.2×10^{-6}.

C. RELIABILITY ALLOCATION AND PREDICTION

An allocation was made early in the program. A reliability prediction was prepared in accordance with the procedures outlined in RADC Reliability Notebook, Volume II (prepared for RADC by Hughes Aircraft Company under Contract No. AF30(602)-4072). In instances where the RADC Reliability Notebook, Volume II, gave no failure rate data on a component, vendor or Honeywell data was used. Due to lack of adequate data, the prediction did not consider performance degradation prior to battery initiation.

D. RELIABILITY ASSESSMENT

Quantitative reliability progress was monitored by assessing the achieved reliability during the contract; however, no formal documentation was generated.

E. CIRCUIT ANALYSIS

A computer aided circuit analysis was conducted to insure that the fuze would function as intended for variations in part parameters over the temperature range.

F. PARTS RELIABILITY PROGRAM

Reliability assurance for parts included critical performance and environmental requirements (e.g., survivability through impact) to assure compatibility with fuze requirements. Part drawings were drafted by a project group composed of parts-assurance engineers, the design engineer, the quality engineer, the production engineer, and the reliability engineer.

Pre-failure analysis was conducted on all semiconductors and tantalum capacitors used in the final development fuze build. Semiconductors were analyzed for bond pull, lead sag, chip anchorage, cracked chips, and surface contamination. Tantalum capacitors were analyzed for voltage breakdown capability, thickness and porosity of MnO_2 layer, and slug anchorage. The effects of these analyses on fuze performance can be seen by reviewing the excellent results obtained during fuze lot sample tests. The lot sample test results are presented in Table II-3.

G. DEVELOPMENT TESTING

Reliability engineering participated in the preparation of test procedures for the batteries, coulometers, system test modules, and fuzes. The procedures included requirements to assure complete and accurate evaluation of all applicable parameters.

H. FAILURE REPORTING, ANALYSIS, AND CORRECTIVE ACTION

Failures of piece parts, modules, and fuzes were analyzed to determine the cause of each failure. When the cause was determined, appropriate corrective action was taken. Failure analysis and the development of the appropriate corrective action were instrumental in improving the reliability and safety of this fuze during the development phase. The failure analysis results of the 81 service test models are summarized in Table VIII of this report.

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APPENDIX I

TERMINAL ENVIRONMENT SENSOR INVESTIGATION

The original TES design criteria was established from the results of tests accomplished by the contractor (17 June 1969) and the sponsor (ADTC-TR-70-196) early in 1969. These tests utilized the basic FMU-63/B inertial switch design set at various G-levels in a manner to determine time of closure for the switch in various bomb operational impact conditions and simulated accidents. From the results of these tests, a decision was made to use 140-g level and 19-millisecond gate width for the low G section of the Service Test Model Fuze Build.

As indicated in the results of the Service Test Model Fuzes, evaluated at the sponsor's facility, the above parameters did not provide reliable function in regarded munitions. Low G-levels were determined to be the cause, based on computer studies of impacts.

Six special TES Recorders were fabricated using the FMU-63/B Initiation Circuit in modules incorporating MK128 (60-g nominal) switches obtained from one of the manufacturers of the MK344 fuze. Table I-1 shows the operational data points gathered by contractor tests (OEXM 23089) and by sponsor tests in conjunction with the Service Test Fuze Program. These data show that use of this switch eliminated the non-arming condition experienced with the 140-g sensitivity level. The basic problem with the Mk128 switch, however, is that it is not omnidirectional. Honeywell Laboratory tests showed that the reliable sensitivity section is limited within approximately ± 60 degrees of the marking in the lateral axis; therefore, for nose and tail sensitivity at least two and preferably four switches would be required.

A program was conducted to sensitize the omnidirectional X67A5365 switch to less than 100 g's and gather additional field test data before establishing the TES parameters for the build of the prototype fuzes. The first 20

TABLE I-1. TEST RESULTS OF FMU-63/B TES MODULES WITH MK 128 SWITCHES

							MODULE POSITION									
							1		2		3		4		5	
			Nominal Settings		Switches Gate	G. Sec.	60/800 22/4		63 22		64 11		68 22		78/800 22/4	
Contractor Field Test 0EXM 23089		Retard or Clean	Drop Height (Feet)	Impact Velocity (FPS)	Impact Angle (Degrees)	Bomb Penetration (Inches)	Nose	Tail	Nose	Tail	Nose	Tail	Nose	Tail	Nose	Tail
↓	M117	C	200	102	50	6	0	0	+	0	+	+	+	0	−	0
	M117	C	345	139	84	12	+	0	+	0	+	+	+	0	−	0
	M117	C	500	(160)	NA	47	+	+	+	+	+	+	0	+	−	+
	M117	C	500	157	83	32	+	+	+	+	+	+	0	+	−	+
	M117	C	500	173	73	38	0	+	0	+	0	+	0	+	−	+
	M117	C	600	187	70	47	+	+	+	+	+	+	+	+	−	+
	M117	C	620	(180)	NA	44	+	+	+	+	+	+	+	+	−	+
	M117	C	750	208	75	38	+	+	+	+	+	+	+	+	−	+
	M117	C	970	(250)	NA	88	+	+	+	+	+	+	+	+	−	+
Sponsor Flight Test	M117	C	500	>750	NA	skip	+	+	+	+	+	+	+	+	−	+
↓	M117	C	2000	>750	NA	NA		+		+		+		+		+
	M117	R	2000	~200	NA	~76	+		0		+		+		−	
	M117	R	2000	~200	NA	~60		●		+		+		●		−
	M117	R	2000	~200	NA	~60	+		●		+		+		+	
	M117	R	2000	~200	NA	~63	+		+		+		+		−	
	M117	R	2000	~200	NA	~69		+		+		+		+		+

Legend:
+ - Go
0 - No Go
● - No Go (Erratic Module Observed in Subsequent Lab Check)

switches tested showed a sensitivity range of approximately 65 $\pm$ 10 g's.

Two additional recorders were fabricated, and the sensitivity range of the switches was modified to 95 $\pm$ 20 g's. Field test data gathered on these switches indicated they were adequate for the FMU-63/B Long Delay Bomb Fuze (ADTC-TR-71-114); these data are summarized in Table I-2.

TABLE I-2. TEST RESULTS OF FMU-63/B TES MODULES WITH OMNIDIRECTIONAL SWITCHES

Recorder #	Range* Switch Sensitivity	Bomb Type	Nose or Tail	Flight or Tower	Height of Drop	Release Velocity	Impact Velocity (calc)	Impact Medium	Drop Attitude	Module Position 1	2	3	4	5
2	50-70	M117	T	Tower	40	0	50 FPS	sand	45°	0	0	—	0	0
1	40-75	↓	N	↓	↓	↓	↓	↓	45°	X	0	X	0	X
2	50-70	↓	T	↓	↓	↓	↓	↓	Vertical	X	0	—	0	0
1	40-75	↓	N	↓	↓	↓	↓	↓	Vertical	X	X	X	0	0
2	50-70	↓	T	↓	↓	↓	↓	↓	Horiz	0	0	—	0	0
1	40-75	M117	N	Tower	40	0	50 FPS	sand	Horiz	X	0	0	0	0
3	55-75	MK82R	N	Flight	4000	400 KIAS	Terminal	sand	S&L	X	X	X	X	X
4	60-80	↓	T	↓	↓	↓	↓	↓	↓	X	X	X	X	X
7	85-105	↓	N	↓	↓	↓	↓	↓	↓	X	X	X	X	X
8	85-95	MK82R	T	Flight	4000	400 KIAS	Terminal	sand	S&L	X	X	—	X	—
3	65-75	MK82R	T	Flight	4000	400 KIAS	Terminal	sand	S&L	X	X	X	X	X
4	55-80	↓	N	↓	↓	↓	↓	↓	↓	X	X	X	X	X
7	75-100	↓	T	↓	↓	↓	↓	↓	↓	X	X	X	X	X
8	85-100	MK82R	N	Flight	4000	400 KIAS	Terminal	sand	S&L	X	X	—	X	—
3	55-75	M117R	N	Flight	500	360 KIAS	234 FPS	asphalt	S&L	X	X	X	X	X
4	60-80	↓	T	↓	↓	↓	↓	↓	↓	X	X	X	X	X
7	85-105	↓	N	↓	↓	↓	↓	↓	↓	X	X	X	X	X
8	85-95	M117R	T	Flight	500	360 KIAS	234 FPS	asphalt	S&L	X	X	—	X	—
7	55-95	M117	T	Tower	40	0	50 FPS	sand	Horiz	0	0	0	0	0
7	70-85	↓	N	↓	↓	↓	↓	sand	45°	0	0	0	0	0
7	50-90	↓	T	↓	↓	↓	↓	sand	90°	0	0	0	0	0
7	70-95	↓	N	↓	↓	↓	↓	steel	45°	X	X	X	0	X
8	90-100	↓	N	↓	↓	↓	↓	sand	Horiz	0	0	—	0	—
8	90-100	↓	T	↓	↓	↓	↓	sand	45°	0	0	—	X	—
8	90-95	↓	N	↓	↓	↓	↓	sand	90°	0	0	—	0	—
8	60-75	M117	T	Tower	40	0	50 FPS	steel	45°	0	0	—	0	—

* Sensitivity checked between subsequent tests

X - TES satisfied

0 - TES not satisfied

APPENDIX II

FUZE, SUBASSEMBLY, AND COMPONENT TEST SUMMARY FOR THE FMU-63/B FUZE DEVELOPMENT PROGRAM

NOTE: The attached listing has been compiled in accordance with Honeywell evaluation test report numbers. These are called OEXM's (contractor assigned test number). They are listed in numerical order under each division and do not reflect a chronological order of testing. The following divisions have been made to group tests that were similar in nature:

1. Fuze Assembly
2. Subassembly (Electronic Modules)
3. S&A Assembly
4. Explosive Train and Explosive Components
5. Inertial Switches
6. Battery Firing Device
7. Battery
8. AD Switches
9. Selector Switches
10. Capacitors
11. Silicon Controlled Rectifiers
12. Resistors
13. Zener Diodes
14. Transistors
15. Electrochemical Timers

1. Fuze Assembly

OEXM

15534 30 Aug 66 20 FMU-63/B Fuzes (Configuration I) 72 hours

Fuze design was basically a modified FMU-35/B. All twenty fuzes satisfactorily passed the acceptance tests before, during, and after the environmental tests. Three out of fourteen failed to come within ± 5 percent of the set times. Battery voltage of the three fuzes tested remained above 9.0V during 72 hours of operation. (See Table II-1.)

16733 28 Feb 68 20 FMU-63/B Fuzes (Configuration III)

Fuze design used FMU-35/B S&A with new electronics packaging. Fuzes were subjected to matrix of environmental exposures and functioned at -65, room and +160° F. The arming section and initial delay circuits functioned properly throughout the program. Misassembly of timing cells in the delay timer caused no-test of that portion of the program.

18908 31 Dec 68 2 Structural Test Models of Configuration V

Simulated Fuze Configuration models were subjected to static and dynamic tests (air gun sabot into sand target at 875 fps). Calculations showed static strength to levels in excess of 10,000 times the supported weight.

21607 2 Feb 70 27 Engineering Test Model Fuzes (X68F5638 Rev. E)

Fuze design contained new hardened S&A concept and updated modular electronics housing. The fuzes were divided into 7 groups of 4 fuzes each (lot 1 had only 3 following delivery of 1 model to AFATL from the 28 models built) and subjected to a series of exposures before initiation.

TABLE II-1. TESTING SEQUENCE

TEST \ SN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	TESTING SEQUENCE																			
INITIAL ACCEPTANCE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TRANSPORTATION VIBRATION							2			3			2			2			2	2
AIRCRAFT VIBRATION								3			2			2			2		3	3
TEMPERATURE-HUMIDITY	2	2	2	2	2															
THERMAL SHOCK						2		2		2									4	4
ALTITUDE									2			2			2			2		
ACOUSTICAL NOISE							3		3											
ELECTROMAGNETIC SUSCEPTIBILITY							4		4											
E-CELL TIMING AT ROOM TEMP. (+ 80°F)							5		5											
E-CELL TIMING AT +160°F		3		3				4		4						3		3		
E-CELL TIMING AT -65°F	3		3		3	3									3		3			

Group 1	Acoustic Noise (MIL-STD-810B method 505 Category B)
	Transportation Vibration (MIL-STD-331, Test 104)
	Aircraft Vibration (MIL-STD-810B Curve J 514.2)
	Retarder Shock Simulator after initiation
	Air Gun at 200 fps into sand
	Timeout at Room Temperature
Group 2	Transportation Vibration at +160°F
	Aircraft Vibration at 160°F
	High Temperature Storage; 28 days at +160°F to +90°F Cycle
	Thermal Shock
	Air Gun at 800 fps into soft catch at +160°F
	Timeout at +160 to +90° cyclic temperature
	Battery life at +160 to +90 cyclic temperature
Group 3	Transportation Vibration at -65°F
	Aircraft Vibration at -65°F
	Temperature - Humidity: 28 days
	Thermal shock
	Air Gun at 800 fps into soft catch at -65°F
	Timeout at -65°F for first 80 hours, then to -40°F
	Battery Life at -40°F
Group 4	Transportation Vibration at room temperature
	Aircraft Vibration at room temperature
	Temperature - Humidity: 14 days
	Thermal Shock
	Air Gun at 800 fps into sand catch at ambient temperature
	Timeout under 25 psig water pressure
	Battery life at room temperature
Group 5	Transportation Vibration at room temperature
	Aircraft Vibration at room temperature
	Thermal shock
	Missile pull-off simulation
	Air Gun at 800 fps into soft catch at ambient temperature
	Battery life at room temperature

Group 6 Transportation Vibration at room temperature
Aircraft Vibration at room temperature
Sand and dust (MIL-STD-810B Method 510)
Catapult and arrested landing simulation
Accidental release simulation
Jettison safety simulation
Static detonator safety (dud firing)
Battery life at room temperature

Group 7 HERO Test (MIL-P-24014)
(2) Initiation without shock in HERO environment
(2) Initiation with shock in HERO environment
Battery life at room temperature

Data was gathered on all six methods of eventing (Normal Timer 1, Normal Timer 2, Anti-tamper, Anti-disturbance, Back-up Timer, and Low Voltage Self-Destruct) from the 27 models. This was accomplished by cutting open the fuzes after the initial event and recycling the electronics. The electronic packages were also returned to the laboratory for performance checks. In this manner maximum data gathering on the complete system was accomplished.

A number of defects were uncovered in this test.

1. Improper assembly techniques caused out-of-tolerance performance from the time base component.
2. Vibration and shock caused degradation of the anti-disturbance feature.
3. Insulation on wiring cracked from aging.
4. Two transistors failed due to mechanical shock.
5. Battery performance degraded by structural failure from high level mechanical shock.
6. Ball seal did not function properly.
7. Printed wiring boards were of poor workmanship and had not been adequately inspected and tested.
8. Tantalum capacitors were of poor workmanship.

9. Inadequate soldering methods caused two failures.

10. One firing actuator failed due to excessive high g mechanical shock.

11. Structural failure of battery sleeve caused seal failures.

12. A number of other reported failures which could not be verified in subsequent failure analysis.

A failure analysis report with dispositions was issued by Design Engineering.

22431 Oct 70 24 Service Test Model Fuzes
(X69F5639 Rev. E)
(X69F5638 Rev. G)

Fuze design was basically the final mechanical and electrical configuration. The twenty-four fuzes were divided into six groups of 4 fuzes each. The first four units were tested and found to have a major workmanship failure on the Number 5 Printed Wiring Board. All subsequent units were revised to correct the fault.

The second group tested was the High Temperature series in which known defects had been identified. These fuzes were tested in such a manner that the defects would not affect the results; however, secondary effects were found that caused test results to be abnormal. The third group tested was assembled from good subassembly sections and subjected to acceptance test prior to delivery of units to the Air Force. Test results were satisfactory with the exception of a random workmanship failure which had been improperly inspected in the test equipment. The remaining three groups of fuzes were subsequently tested following specific serial environmental exposures:

Group ST-1 Thermal Shock
12 Hour Transportation Vibration
9 Hour Aircraft Vibration

Group ST-2	26-Day High Temperature Storage 27-Hour High Temperature Transportation Vibration 9-Hour High Temperature Aircraft Vibration Thermal Shock
Group ST-3	28-Day Temperature-Humidity Storage Thermal Shock 12-Hour Low Temperature Transportation Vibration 9-Hour Low Temperature Aircraft Vibration
Group ST-4	14-Day Temperature - Humidity Storage 27-Hour Transportation Vibration 9-Hour Aircraft Vibration
Group ST-5	36-Inch Drop in Container 30-Minute Recurring Impact in Container 222-Minute Transportation Vibration in Container 9-Hour Aircraft Vibration
Group ST-6	NONE

In the same manner as in OEXM 21607, test of the Engineering Model Fuzes, all possible data was gathered on all six methods of eventing.

A number of defects was again uncovered in this test series, beyond those which were corrected before the build of the items shipped for AF evaluation.

- One explosive switch ruptured internally.
- The low voltage self-destruct circuit was observed to be inoperative with high impedance battery.
- Event times were out of tolerance due to use of unqualified electro-chemical timers.
- Dial assemblies froze from surface moisture at low temperature following humidity exposure.
- The ball seal was not adequate.
- The BFD self-initiated in missile pulloff simulation.

- One piston actuator bridge wire opened due to high impact shock.
- Three components fractured due to inadequate support from potting materials during high g shock.
- Selector switches were not adequately sealed against potting leakage.
- Booster spacer was not adequately fastened to container by adhesive only.
- A number of nuisance-type items which did not affect circuit performance.

Only high shock and waterproofness tests appeared to cause consistent performance degradation.

A failure analysis and disposition report was issued by Design Engineering.

<u>ETR 1022</u> Bonding of Booster Spacer to Container
Lap shear strengths in excess of 2800 psi existed after thermal shock and 14-day temperature and humidity tests.

<u>ETR 5361</u> Fusion Weld of Container
Weld zone was brittle due to failure of vendor to anneal after welding. Print note revisions are recommended.

<u>23818</u> 8 Container Assemblies
Static Detonator Safety Tests were conducted at -80°F, room temperature, and +160°F on fuze container X68C5215 Revision J. Endplate welds on the containers had been tempered but did not have full penetration per print. Windows were brazed. Test was passed satisfactorily.

<u>23485</u> Dial Shutter Seal
A series of tests were run to determine the capability of the relocated Safing Pin Seal to meet a 10^{-4} ATM cc/sec equivalent leak requirement. O-ring sizes were chosen, and parts were shimmed to simulate minimum and maximum squeeze conditions. The resulting design passed firing and sealing tests over the full temperature range.

23543 10 FMU-63/B Prototype Fuzes

Prior to commitment of the fuze configuration for the final prototype delivery, 10 fuzes were built and tested in various environments at the contractor's facilities. All tests included air gun shock exposures after battery initiation. A major defect was revealed in the lot of explosive switches. The results of these tests are presented in Table II-2.

23575 12 Fuze Assemblies 68F5639

During build of the 328 Prototype fuzes, eleven lot samples tests were conducted in accordance with the quality conformance requirements (modified) of the Preliminary CEI Detail Spec XCP 68F6675 dated 5/17/71. Results are given in Table II-3.

TABLE II-2. LOT TEST RESULTS

GROUP	FUZE	TEMPERATURE	INITIATION		EVENT	
			DATE	SET TIME	DATE	ACTUAL TIME
I	1	AMBIENT	6/23	24	6/24	23:52
	2	AMBIENT	6/23	24	6/24	24:01
	3	160°	6/23	192	7/1	189:12
	4	160°	6/23	192	7/1	190:10
II	5	AMBIENT	6/30	171	7/7	171:12
	6	AMBIENT	6/30	172	7/7	158:34
	7	-65°	6/30	41	7/2	42:03
	8	-65°	6/30	18	7/1	DNE*
III	9	AMBIENT	7/7	23	7/8	23:01
	10	AMBIENT	7/7	23	7/8	23:02

DNE* DID NOT EVENT DUE TO EXPLOSIVE SWITCH QUALITY FAILURE.

GROUP I	AIRCRAFT VIBRATION TRANSPORTATION VIBRATION AIR GUN TIME-OUT (2 AMBIENT) (2 + 160°F)
GROUP II	THERMAL SHOCK AIRCRAFT VIBRATION WATERPROOF AT 15 PSI AIR GUN TIME-OUT (2 UNDERWATER) (2 -65°F)
GROUP III	ROUGH HANDLING AIR GUN TIME-OUT (2 AMBIENT)

TABLE II-3. LOT SAMPLE TEST RESULTS

DATE	LOT NO.	FUZE S/N	CONFIGURATION	PRE-INITIATION ENVIRONMENT	OPERATING TEMPERATURE (°F)	PIT (SEC)	ILAT (MIN:SEC)	DELAY TIME		COMMENT
								SET (HR)	ACTUAL (HR:MIN)	
7/29	E2-2	0125	A	TRANSPORTATION AND AIRCRAFT VIBRATION	ROOM	2.2	21:33	16	16:04	
7/29	E2-2	0139	A	TRANSPORTATION AND AIRCRAFT VIBRATION	ROOM	2.7	21:32	16	16:02	
8/5	E3-1	0147	A	TRANSPORTATION VIBRATION	-65	2.7	21:53	17	17:19	
8/26	E5-1	0304	B	TRANSPORTATION VIBRATION	ROOM	2.5	22:00	24	AD	a
8/26	E4-1	0171	A	TRANSPORTATION VIBRATION	-160	2.0	21:55	19	19:04	
9/14	E6-1	0404	C	TRANSPORTATION VIBRATION	ROOM	2.7	21:25	18	18:01	
9/23	E6-2	0431	C	TRANSPORTATION VIBRATION	ROOM	NONE	NONE	1	NONE	b
9/30	E6-3	0445	C	TRANSPORTATION VIBRATION	-65	2.4	20:03	11	10:49	
10/8	E7-1	0502	D	TRANSPORTATION VIBRATION	ROOM	2.4	19:50	17	17:00	d
10/21	E7-2	0532	D	TRANSPORTATION VIBRATION	ROOM	2.2	19:50	16	16:00	
10/28	E7-3	0556	D	TRANSPORTATION VIBRATION AND WATER	ROOM	NONE	NONE	19	NONE	c
11/4	E7-4	0564	D	TRANSPORTATION VIBRATION AND WATER	ROOM	2.2	19:36	18	17:54	

a -- INTENTIONALLY EVENTED BY ANTIDISTURBANCE CIRCUIT AT APPROXIMATELY 16 HOURS.
b -- ACTUALLY SET IN "SAFE" POSITION AND DUDDED IN NORMAL SELF CHECK.
c -- SCREW LYING ON BATTERY PRIMER PREVENTED INITIATION ON FIRST ATTEMPT.
d -- UNIT DUDDED WHEN SELF CHECK FOUND SOLDER BRIDGE ON S7 N.O. CONTACTS.

OEXM 24506 — Containers

X69D4742

Testing was accomplished at -80°F, room temperature, and +160°F to evaluate the integrity of the proposed solder installation of the window into the container in place of the braze evaluated on OEXM 23818. Test was satisfactory.

OEXM 24531 — 17 Fuze Assemblies

X68F6675

A modified hazard test was accomplished per TO11A-1-47, using 15 of the 17 fuzes provided by the contract. No hazards were detected for fuzes evented in the ammunition box.

2. Subassemblies (Electronics Modules)

OEXM

16735 — 24 Oct 67 — 110 Timing Circuit Modules #28002386

Data gathered on potted modules (Configuration III) using different components for performance evaluation over extreme temperature range and extreme battery voltage. E-cell timeouts (12-hour and 120-hour) showed 0 to -5.5 percent accuracy on 41 units tested over the extreme temperature range with six no-test and two electrical component failures. Voltage regulator load test showed 21-millivolt output drop at $60\mu A$ load over temperature extremes. The low-voltage-self-destruct voltage is normally approximately 6.2 V at room temperature; this decreased to 6.0 or less at +160°F and increased to 6.4 or above at -65°F. Noise on B+ power supply increased LVSD by 0.1 volt.

19633 — 20 Feb 70 — 46 Timing Circuit Modules #28100077

Modules consisting of the proposed fuze voltage regulator, and LVSD circuits, in addition to gathering data on module performance over the extreme temperature range, were run out with E-cells attached. With the exception of a number of

short time-outs using E-cells of a non-qualified type the modules showed only one component failure (Q_5 NPN Transistor).

7 units remained within tolerance at all temperatures and voltages.

35 units displayed low output (to 2.4 percent) at 7.0V B+.

4 units displayed low output (to 1.9 percent) at 7.0V and high output (to 1.2 percent) at +13.0V

Output of second stage of regulator is approximately .03V (-.5 percent) maximum below V_R at all conditions.
LVSD decreases approximately .5V from maximum at -55°C to minimum at +71°C.

	-55	Room	+71
Maximum recorded LVSD	7.54	6.65	6.52
Minimum recorded LVSD	6.68	6.41	6.26

Regulator output dropped less than .03V when load was increased from 5 μA to 120 μA at each temperature and voltage condition.

Thermal shock had no effect on module performance.

22427 20 May 70 49 Timing Circuit Modules #28100077

Modules were similar to units tested in OEXM 19633 except for modification to stabilize LVSD and V_R.

44 units remained within tolerance at all temperatures and voltages

1 unit displayed high output (to 1.9 percent) at 13.0V B+ -55°C.

1 unit failed at temperature extreme.

3 units displayed low output (to -1.3 percent) at 7.2V B+ +72°C.

Output of second stage of regulator is approximately 0.025V (-0.4 percent) maximum below V_R at all conditions.

LVSD decreases approximately 0.6V from maximum at -55°C to +72°C.

	-55°C	Room	+72°C
Maximum recorded LVSD	6.99	6.78	6.63
Mediam point LVSD	6.83	6.59	6.38
Minimum recorded LVSD	6.57	6.40	6.24

3 reference transistors (63A11572) broke down during test.

2 PNP transistors faulty.

E-cell Performance

Units within Spec/Units Tested

	-55°C	Room	+72°C	
6 Minutes	3/3	3/3	3/3	Gibbs
40 Minutes	4/5	3/4	5/5	Gibbs
10 Hours	4/5	4/4	6/6	BB
12 Hours	2/5	-	0/2	Gibbs
180 Hours	4/4	3/4	5/5	BB

<u>22446</u> 17 June 70 77 Initiation Modules

Test to evaluate temperature and voltage level effects on calibrated times for high-g and low-g operation and pre-impact timer. Nominal times and sigma (10.5V B+) were:

	-55°C		Room		+72°C	
Pre-Impact Timer (sec)	2.48	(.11)	2.27	(.03)	2.25	(.06)
High-g (millisec)	4.50	(.15)	4.05	(.13)	3.84	(.09)
Low-g (millisec)	22.5	(0.7)	18.4	(0.2)	16.7	(0.2)

Battery voltage increase from 9.5V to 11.5V:

Decreased PIT times less than 2 percent

Changed High-g times less than ± 8 percent

Changed Low-g times less than ± 4 percent

23089 Jan 71 2 TES Recorders with 5 Initiation Circuit Modules Each.

The Terminal Environment Sensor (Initiation Circuit Modules) was demonstrated to function at all impact velocities above 175 fps in M117 bomb when MK128 Mod 0 switches were used as g level sensors.

23811 8 Field Test Electronic Assemblies

A sensitivity check was made on the inertial switches of fuzes returned from field test. Both high-g and low-g switches were found to be deformed, evidently from the excessive g-loads from high impulse factors during bomb impact against targets at high velocity. One switch was found to contain potting material caused by an inadequate seal before potting.

23824 Eight recorders were built each containing five Initiation Circuit Modules (P/N 28000882 as tested in OEXM 22446) modified per latest circuit changes and to function from internal power supply. Contractor tests were limited to sensitivity checks of the units only. Contract sponsor tested the items in flight to determine that the proposed increased sensitivity of the TES would be adequate to improve the fuze performance in retarded munition delivery. The tests showed that a 60-g nominal level was too sensitive and that a 95-g nominal level was satisfactory for flight drops (24/24 impacts against sand and asphalt). Report of field test was written by the sponsor (ADTC-TR-71-114).

3. S&A Assembly

OEXM

18874 9 Feb 69 Simulated Gag Rod and Slider

Lateral shock tests on 40-foot drop tower proved gag rod (retainer) strength to maintain position. Piston actuator bent rod satisfactorily in subsequent test. Aluminum slider was driven to in-line position in approximately 0.0007 second with slight rebound at stop.

20401 19 Nov 69 20 S&A Assemblies W/X68D5640 Rev. B Interrupter (no sear)

The assemblies proved to be fully operable following vibration and shock tests. As also demonstrated in component testing of piston actuators (OEXM 20397 and 20406), a problem existed with the ability of the then current actuator design to withstand high g mechanical shock. The test also proved the need to improve the method of installing the detonator in the interruptor.

Slow cookoff on the explosive elements resulted in M55 detonators functioning at 199°C and actuators desensitized with slight piston movement at 177 to 188°C except for one unit which functioned at 210°C. The S&A's proved to be safe and operable following -

(a)	Vibration	24 Hours	10-500 cps	5 g's followed by
		9 Hours	5-2000 cps	5 g's

(b) 5-Foot Drop in 59.2-pound fixture

(c) 40-Foot Drop in 59.2-pound fixture

Six S&A assemblies (initiated with lead cup) worked properly at temperature extremes. Unsupported container was inadequate in high g shock tests.

21145 Nov 70 S&A Slider Stop Assembly

A device to prevent momentary in-line position of the interrupter at impact was demonstrated to be functional for S&A design not employing a fixed sear detent.

22110 29 Dec 69 3 S&A Assemblies. (68F5641 Rev. H reference)

Test was conducted to investigate ability of the current gag retention method to retain the gag against aircraft vibration. All three gags moved out of position at less than 2 g.

22111 29 Dec 69 3 S&A Assemblies from OEXM 21607 Fuzes

Failure analysis of safe and arm mechanisms from fuze test showed the piston actuators functioned satisfactorily.

22126 11 Feb 70 4 S&A Assemblies

Static detonator safety tests run at room temperature showed that the lead cup assembly (PBX-N5) was not initiated when the detonator was fired in its normal out-of-line position. Structural damage did occur, which caused ejection of the lead cup assembly.

22135 30 Jan 70 2 S&A Assemblies – modified for detented gag.

Two modifications were tested toward meeting a proposed 10-g vibration requirement in which the gag must stay in position. Both units met the requirement as tested in 50 minutes of sweep at 10 g's from 500 to 2000 cps (approximately 1000 g's resonant frequency observed).

22454 Jan 71 9 S&A Assemblies – modified for detented gag (X68F5641 Rev. H Modified to J).

Tests were conducted on the detented gag configuration and arming section. The design met the 10-g sine and .4 g^2/Hz noise requirements. On impact, set was gained at approximately 30 g's with 20 msec pulse width, and the gag remained detented out of line against shocks to 5300 g's.

Out-of-line safety test revealed inadequate weld in fabrication of the containers.

A 13-percent undersize safing pin held the interrupter against the arming actuator load.

4. Explosive Train and Explosive Components

OEXM

13495 30 Sept 68 M55 Detonator, Lot #L.S. 94-47.
Comp. A-4 Booster. Lot #HOL 33-7 Batch 886-7, 1.693 GM/CC 12 GM
Maximum Booster

Three simulated explosive trains were fired with zero gap. All failed to initiate the booster (booster was shattered to

powder). Out-of-line safety test was performed and proved successful as the barrier shield of 0.052 inch steel was not penetrated.

18764 20 Sept 68 7 1MT114 Piston Actuators and M55 Detonators

Room temperature and -65°F firing of PA initiated all detonators when firing pin (28000796) was mounted on piston. Blunt end piston did not initiate detonator at ambient temperature.

18774 11 Sept 68 50 Trials with M55 detonator PBX-N5 lead
Comp A4 booster
Simulated Container and Interrupter

Bruceton tests were run to determine mean and standard deviation of distance at which initiation occurs between (1) lead and booster and (2) parallel longitudinal center lines of detonator and lead.

X (in.)	σ (in.)	
0.330	0.058	lead to booster gap
0.219	0.006	centerline displacement

20397 28 Aug 69 188 Piston Actuators
94 5349-1 piston
94 5349-2 firing pin

Both types of actuators appear to be acceptable according to 5349 specification except when exposed to high g-level mechanical shock. Ninety-four of each type actuator were subjected to qualification test-type evaluation.

- Bridge resistance basically 3.2 to 4.4 ohms.
- Bridge resistance changed less than 0.1 ohm at temperature extremes.
- No-fire test at 100 ma for 5 minutes was satisfactory.
- Firing piston velocity measured at 98 fps maximum.
- 50 units functioned properly after thermal shock.
- Both type actuators showed mechanical difficulty to a certain degree from air gun shock.

- 36 units functioned properly after vibration test.
- 12 units functioned properly after extreme temperature storage.
- Temperature and humidity testing was improperly conducted.

20398 21 May 69 9 Piston Actuators

Low temperature firing of the piston actuators at minimum specified firing voltages was satisfactory

For 5349-1 5.25 + 0.10 volts on K220P6

For 5349-2 4.70 + 0.10 volts on K220P6

18 percent undersize safing wire satisfactorily retained the interrupter in out-of-line position against actuator force. Firing of the two out-of-line satisfactorily retained the interrupter out-of-line against the arming actuator force.

20406 4 Aug 69 10 Piston Actuators for Electrical BFD (28101744).

Test verified that the ten firing circuits were properly initiated from a power source simulating the AN/AWW-4 system (+195 VDC, 1.0 ampere, 4.5 millisecond pulse)

20410 14 Oct 69 100 Explosive Switches (X69A4556)

A control group of 25 units was fired at temperature extreme, function tests conducted on 55 units at -65, room, and +160°F following exposure to thermal shock, vibration, extreme temperature storage, and temperature and humidity testing indicates that all units functioned normally. Seven of 20 units tested following high g mechanical shock in air gun did not fire due to open or shorted bridge wire.

20411 6 March 70 15 Electrical Battery Firing Devices (28101192).

Post test results were satisfactory on all units following exposure to a matrix of environments. Bare BFD's were exposed to temperature and humidity, temperature storage, salt spray, rain and ice, and RF susceptibility (MIL-P-24014). Five-foot drop, 40-foot drop, safe jettison simulation, and missile pull-off simulation were accomplished with the units assembled to dummy fuzes and tested in fixtures simulating fuze wells.

Piston velocities of 240 fps were measured.

20431 19 Nov 69 12 Lead Cups (X68A6760)

The test proved that the lead cup will not be initiated in case of firing pin impact at velocity up to 220 fps (See OEXM 20436) with no interrupter in place. Firing tests on OEXM 22431 (on recycled units fired without detonator) showed that the piston may be expected to be restrained from touching the lead cup even without the interrupter.

20435 20 Nov 69 20 Explosive Switches – Atlas Type MMS 1.1-0-A

The test of these special switches was made to determine whether they would be a satisfactory backup design for the X69A4556 requirement. Only the high g mechanical shock exposure was conducted, following which all parameters were normal and the units functioned properly.

20436 24 Nov 69 3 Piston Actuators (X68A5349-2)

The maximum velocity attained by pistons having the restraining crimp removed and at the distance equal to the lead cup to actuator installation (approximately 0.17 inch) is less than 200 fps.

22091 10 Oct 70 6 Explosive Trains Including FZU-2/B Booster

The fuze explosive train functioned normally with a gap between lead cup and booster up to 1/4 inch and with normal installation flooded with water. The booster was shattered but did not detonate with 1/4 inch gap flooded with water.

22123 11 May 70 10 Explosive Switches X69A4556 (PO#874857)

These switches were an improved model of switch tested in 20410. All units functioned properly after mechanical shock although one unit had open bridge wire when continuity tested before firing.

22124 22 April 70 20 Piston Actuators X68A5349 (PO#874854, 5)

Design modifications incorporated by the vendor to improve the mechanical shock and cook-off capabilities of the actuator were evaluated in an air gun test. The mechanical shock fix proved inadequate in retaining the piston retracted. All but one unit

fired properly after shock when using extreme temperatures for firing performance data. The one unit had an open bridge wire. Vendor stated that inadequate weld schedule was most likely the cause and that inadequate piece part control of redesigned parts had caused failure of piston retention mechanism.

22125 20 Jan 70 50 M55 Detonators

14 Lead Assemblies
X68A6760 Rev. B

Salt water immersion at 25 psi for 200 hours proved to have little or no effect on sealed or unsealed lead assemblies. Detonators with broken seals were seriously affected when 7 of 10 failed to initiate. Detonators sealed with epoxy initiated high order in all forty cases.

22411 10 June 70 100 Piston Actuators
68A5349-3 (PO#874856)

Units met qualification requirements of specification except for one unit (of 15 tested) which did not fire following temperature and humidity exposure. Mechanical shock (air gun) test and static voltage check were not conducted.

Cook-off temperature minimum was 255°C.

22470 Oct 70 20 Explosive Switches
X69A4556

Atlantic Research Corporation (Saugus) standard MK127 switch. Ten of ten switches passed soft catch air gun test. Five of five passed hard catch tail fuze position. Three of five failed to function after hard catch nose fuze position.

22604 2 June 70 5 Piston Actuators
X68A5349-2

Testing was accomplished to prove adequacy of use of external shear washer to retain the piston, which extended in previous test (OEXM 22124). Similar washer had proved adequate in previous fuze evaluation. Ability to fire the M55 detonator was shown in all 5 units (3 at room temperature, 2 at -65°G).

ETR 980 Compatibility of PBXN-5 with BF Goodrich A1177B. PBXN-5 decomposed at 268°C. No degradation.

5. Inertial Switches

OEXM

18054 9 Mar 68 12 Impact Sensors (4 each of 3 types)

Random noise, centrifuge, and shock tests were conducted to gather performance data on standard and modified switches based on production model MK128 and FMU-26/B type switches plus modified FMU-26/B switches with special end cap to increase sensitivity. Modified switch proved equal to MK128 with omnidirectional capability.

18904 10 Feb 69 22 Impact Switches of each of Two Types – Low g and High g

Low g sensitivity was minimum of 90 g's and high g was minimum of 900 g's with excessive tolerance. All switches showed capability of not closing under 15-g random vibration level, or 20-g sine wave to 2000 cps. Data gathered on impact response at low level and 40-foot level drop testing showed low-g switch closed maximum of 10 msec.

21180 20 Oct 69 97 Inertial Switches X68A5365

Data was gathered on switch sensitivities in all three axis to check for uniformity of performance as well as establish nominal sensitivity of the designs of both high-g and low-g configurations. Data scatter was excessive, and visual inspection revealed dimensional control of assemblies exceeded drawing limits. Longitudinal axis sensitivity exceeded lateral sensitivity in excess of 30 percent and nominal sensitivities were 180 g's and 670 g's.

21641 16 Jan 70 53 Inertial Switches, X68A5365

Data was gathered on switches assembled in production area using redesign and improved fixturing from OEXM 21180, above. Sensitivity data was gathered per random vibration, mechanical

shock, and acceleration requirements of the switch specification. All but 6 of the 27 low g switches were insensitive to 20-g random noise. Basic design of high-g switch resulted and screening methods were better developed. Non uniform low g performance continued to exist.

21664 15 Inertial Switches

Acceleration data gathered to check sensitivity of low g design. Three-blade switch configuration with thin blades was evaluated toward lowering nominal sensitivity showed distinctive triangular sensitivity.

21681 30 Jan 70 3 Inertial Switches

Data gathered on revised low-g switch design showed improved sensitivity (to approximately 110 g nominal) in all but the cloverleaf pattern. Increased slug weight (hevi-met) and 0.220 housing I.D. plus 0.010 thick blades and 0.040 lengthened blades lowered sensitivity to less than 100 g's.

21700 11 Mar 70 297 Inertial Switches, X68A5365

One lot of 134 high-g switches (68A5281) and one lot of 163 low-g switches (68A5287) were subjected to centrifuge screening. Nominal sensitivities were:

low-g	-	139.7 g's nominal	1σ = 22 g's
high-g	-	1029 g's nominal	1σ = 178 g's

High-limit and low-limit samples were chosen for further engineering evaluation (see OEXM 22402). The remainder of the lot was screened to eliminate switches of low sensitivity (miscentered slug, long blades, or thin blades indicated) to provide components for build of the 105 service test fuzes. (See OEXM 22431 for Test Report on 24 fuzes.)

22402 Dec 70 Inertial Switches – 20 Switches
10 68A5365-1
10 68A5365-2

Switches were tested against requirements of X68A5365 drawing.

Switches were chosen in high, medium, and low ranges from screening of larger production lot using x prime axis only.

From low-g longitudinal screening the mid-range (120 - 145 g) appears to provide more uniform switches in the lateral axis. Both high and low range (above 150 g's or below 100 g's) occurred along with out-of-specification lateral g performance and with vibration sensitivity in the case of low range.

The high-g longitudinal screening was not as uniform as the low-g, and more data should be gathered on this method of sorting.

23065 Oct 70 2 Inertial Switches

Two switches returned from Eglin flight test were calibration checked on centrifuge. One switch was within calibration in both directions of longitudinal axis of fuze. The second was approximately 3 percent high in one direction and within calibration in the other.

23075 Nov 70 8 Inertial Switches

Three low-g switches returned as part of fuzes from field test (including aircraft drop) had calibration of 140 +35 - 22 g's against a standard acceptance of 140 $\pm$ 20 g's. The fourth switch was found to contain potting material which made it inoperative.

Four high-g switches were calibration checked for other testing.

23089 Jan 71 30 Switches, Inertial - MK128 Mod. O

Centrifuge tests showed 58 to 89-g sensitivity level. In lateral axis only about 60 degrees each side of the central reference can be relied to have the necessary sensitivity. No switch chatter was observed during sine wave vibration to 20 g's, and no persistent chatter existed under 23.9-g rms noise vibration. Shock tower testing up to 60 fps velocity change caused switch closures up to 13.5-msec duration.

Field tests of TES recorders using switches from this lot were accomplished over impact velocity ranges from 100 to 250 fps in dummy M117 bomb. Consistent go signal existed at velocities above 175 fps.

Analysis Report | 17 June 1969 | Terminal Environment Sensor (Impact Recorder)

Laboratory and field tests were conducted on impact switches with sensitivity levels from 140 g's to 2100 g's. Based on the results of impacts with velocity changes from simulated accidents, as well as from operational bomb drops, the 140-g sensitivity level with a 19-millisecond time gate was recommended for the low g TES setting. Additional testing was also recommended to be conducted at the sponsor's facility using other target material and other bomb configurations.

OEXM | Inertial Switches

24515 | X68C5287

Test was accomplished on the improved lot-g switch in accordance with requirements of X68Z5365 source control drawing to gather data to update the performance requirements of the drawing.

6. Battery Firing Devices

OEXM

17302 | Oct 67 | Battery Firing Devices

Preliminary data on initial impact-proof BFD Concept. 3200 g's at 0.9 msec triangular pulse on 40-foot tower. Test with FMU-35/B type hardware. Modification to container required to prevent punching out insert. No formal report was issued.

20201 | 20 Mechanical Battery Firing Devices

Initial testing revealed no major problem with the design after exposure to various environments. Design changes made to decrease suspected sensitivity to impact initiation showed

satisfactory performance in tower tests to the structural limit of the firing pin.

23486 Improved BFD

Tests were conducted on a concept model sensor and development models of the BFD configuration proposed to prevent BFD firing during accidental release test (Honeywell drawing 28105054). Two development models were shock tower tested in a manner to pull the lanyard during impact. TER ejection and BFD firing was accomplished on one unit installed in the bomb in a laboratory test. All tests were satisfactory. A similar test was accomplished on two of the twelve field evaluation units built for shipment to the sponsor. Field evaluation will be reported by the sponsor.

7. Battery

OEXM

16717 29 June 67 164 Liquid Ammonia Batteries
FMU-35/B Type X67A11572

Group 1 Initial Qualification Test on 50 Batteries exposed to matrix of High Temperature, Thermal Shock, Temperature-Humidity, and Transportation Vibration requirements. Initiated and tested at +160°F and -65°F. Internal impedance was measured each 24 hours. Temperature extremes shorten battery life up to 50 percent and temperature and humidity reduces life approximately 20 percent (with 5K-ohm load).

Group 2 Initiated at +160°F and -65°F. 7-1/2-ohm load added and life test run at room temperature or -55°F. Room temperature batteries had longer life by approximately 200 per cent.

Group 3 Initiated at room temperature and life tested at room temperature or -65°F with open circuit, 18K, 7-1/2K or 3.9K-ohm load. Open circuit units contained more than 6.0V level for an excess of 2500 hours. Average battery life to 6.0V, 1480 hours at open; 790 hours at 18K; 600 hours at 7-1/2 K; 370 hours at 3.9K.

17259 7 Sept 67 22 G2942 A1 Liquid Ammonia Batteries Lot 1-25 FMU-35/B Type

Fifteen of eighteen batteries tested at temperatures (per MIL-STD-210 type cycling) remained above 6.0 volts for more than 200 hours with 6.8K ohm load. Batteries with shorted terminals recovered to above 4V for periods in excess of 90 hours after initiation.

18218 19 Mar 68 6 G2492 Batteries.

Cookoff test to simulate warehouse fire using slow heating and rapid heating to +650°F. No violent eruptions occurred. Ammonia gas was expelled. Batteries initiated to above 1.0V output at 200°F, 5.0V maximum on slow (10°/100 minutes) rise. Full voltage within 10 minutes on rapid heating, but decayed to less than 3 volts at 10 minutes, rise to 6 volts momentarily on cooling. (See ETR 2829 for post-mortem analysis.)

21607 2 Feb 70 27 Engineering Model Fuzes

Battery data was gathered in support of the fuze test program, and life data was taken with 8.2K ohm resistor load following removal of the electronics section. Voltage stayed above 6.4V for more than 900 hours on one unit and for more than 600 hours on fourteen units. (See report on fuzes.)

21750 4 Nov 70 50 Liquid Ammonia Batteries - X67A7709.

Qualification test was run per specification. Batteries displayed excessive capacity under all normal conditions except when tested following extended Temperature-Humidity and high Mechanical

Shock. (See post-mortem analysis Report ETR 5047 - Broken RTV bonds and KM-16 seal.)

22308 13 July 70 21 Liquid Ammonia Batteries.

Test to obtain battery life with 2K and 4K ohm resistive load at temperature extremes and following Temperature-Humidity. All batteries with 4K load (13) exceeded 270 hours to 7.0 volts. Batteries with 2K ohm (8) exceeded 90 hours to 6.0 volts. Output noise was less than specified maximum.

8. A.D. Switches

OEXM

20172 21 Jan 69 3 Switches Types

Data gathering to test ability of purchased switches to meet the requirement of X67D9102. Three-ball switches most sensitive with 6 or more closures per revolution at most angles of tilt.

21173 26 Aug 69 37 A.D. Switches – X67D9102

Three of the switches were screened out as not meeting the 8 closure/360° requirement of the drawing.

9. Selector Switches

OEXM

21144 4 May 70 60 Selector Switches - X67A8928

The switch demonstrated capability of meeting all the qualification requirements of the specification. One switch of 30 tested showed a shorted condition following water seal test, which caused slightly excessive initial torque in subsequent low temperature test, but which disappeared following later vibration test. Two switches changed one position as a result of the high-g mechanical shock in the air gun.

22117 31 Mar 70 325 Selector Switches - (X68A6694-2)

Presents qualification test data on switches evaluated for use in the FMU-81/B. Testing is equivalent to X67A8928 requirement for switches in the FMU-63/B; therefore, this report is the

basis for acceptance of Daven Corporation as second source for the X67A8928 switch.

10. Capacitors

OEXM

16727 23 Aug 67 15 Mallory MTP-107 Tantalum Wet Slug 100-uf 10V

Temperature cycle, high temperature storage and 40-foot drop tower shocks caused no significant performance changes.

21796 4 Mar 70 25 Capacitors, Ceramic - X69A4562

Units from Cal-R Incorporated met the specification requirements following air gun shock test.

22316 17 June 70 225 Tantalum Capacitors - X68A5627

All of the capacitors met the requirements for full qualification per revision C of the specification.

11. Silicon Controlled Rectifiers

OEXM

21686 6 Mar 70 195 SCR's - X67A8693

The units, supplied by Solid State Products, Inc., met the full requirements of the qualification testing of the specification except for one unit of 24 which was reported to have failed from high-g mechanical shock. Failure was not verified in F&A.

12. Resistors

22332 5 May 70 60 Resistors
X67A8896
X69A4565

Resistors from F.T.I., Mepco, and Allen Bradley met the requirements imposed by qualification testing per the appropriate specification, except that a lower peak g mechanical shock (air gun shock) was utilized.

13. Zener Diodes

OEXM

21678 17 Mar 70 241 Zener Diodes - X69A4563

241 diodes manufactured by Continental Device Corporation met all portions of the qualification specification except for the high-g mechanical shock. A lower level shock proved satisfactory on 53 diodes from various sources, including Control Data Corporation, Motorola, TRW, and Dickson.

22419 1 May 70 24 Zener Diodes - X67A8695

Diodes manufactured by Motorola demonstrated ability to meet the requirements of the specification, except for mechanical shock which was not accomplished.

14. Transistors

OEXM

22420 2 June 70 48 JFE Transistors - X67A8690

All of the samples submitted by Siliconix (6935) met the electrical post potting, thermal shock and vibration requirements of the specification. Mechanical shock test was not accomplished.

15. Electrochemical Timers

OEXM

18140

18225 Bissett and Berman Cells - Low Temperature - High Current Tests (to 360 μA).

Qualification testing of 960 μA hour capacity cells manufactured by Bissett and Berman (S160 11/68). With the exception of one cell tested at 60 μA and -55°C, which was found to have an entrapped air bubble, all cells timed out within 1 percent of the allowed limits. Storage test of six months at +71°C on bare anode units with diode shunts showed 30-second minimum timeout at 180 μA.

22336 23 April 70 270 Electrochemical Timers - 67A56590-1. Qualification testing of 60 μA hour capacity cells submitted by Gibbs Manufacturing (Date Code 7044 and 0006) was terminated when excessive out-of-specification time-outs were encountered on the initial quantity tested.

22376 50 Electrochemical Timers - 67A56590-1. A group of Air Force timers (lot No. 6 6/70) separated into five groups, each potted. Run-out at -65° (180 μA), room temperature (6 μA), and +160 (6 μA) on successive weeks after +160°F storage showed good storage stability. A leakage of electrolyte at the anode seal existed on three of the fifty items.

ETR 5294 Dec 1970 100 E-cells
ETR 5330 56590-1

Cells tested for degradation due to high temperature storage up to 28 days, all performed within specification.

APPENDIX III

COMPLIANCE WITH FUZE SAFETY CRITERIA

Table III-1 summarizes the FMU-63/B compliance to design requirements and objectives specified in the fuze safety criteria.

TABLE III-1. FUZE SAFETY CRITERIA COMPLIANCE SUMMARY

A. DESIGN REQUIREMENTS	FMU-63/B FUZE
(1) FIRING TRAIN INTERRUPTION - ALL FIRING TRAINS WILL INCORPORATE AN INTERRUPTER TO PREVENT INADVERTENT MUNITION FUNCTION BEFORE ARMING. WHEN THE EXPLOSIVE TRAIN INCLUDES PRIMARY EXPLOSIVES (MATERIALS MORE SENSITIVE THAN LEAD AND BOOSTER EXPLOSIVES), AN INTERRUPTER SHALL SEPARATE THE PRIMARY EXPLOSIVES FROM THE MAIN CHARGE.	REQUIREMENT IS SATISFIED. DETONATOR IS INTEGRATED WITH SLIDING INTERRUPTER WHICH MAINTAINS DETONATOR OUT-OF-LINE WITH FIRING PIN PISTON ACTUATOR AN EXPLOSIVE TRAIN.
(2) EXPLOSIVE SENSITIVITY - THE FOLLOWING EXPLOSIVES ONLY ARE PERMITTED IN A POSITION LEADING TO THE INITIATION OF THE MAIN CHARGE WITHOUT INTERRUPTION WHEN THE FUZE IS IN A SAFE CONDITION. (a) TETRYL, MIL-T-0039A (b) CH 6, MIL-R-21723 (c) PBXN-5 GR A-WS-4660-B (d) HNS, TYPE I OR II, GRADE A, WS-5003 (e) RDX, MIL-R-398C (f) TETRYL PELLETS, MIL-P-46464	REQUIREMENT IS SATISFIED. THE EXTERNALLY MOUNTED LEAD CUP IS OF PBXN-5.
(3) SAFE ARM INDICATION - ONE OR MORE OF THE FOLLOWING OPTIONS SHALL BE SELECTED IN THE FUZE DESIGN. (a) A POSITIVE MEANS OF DETERMINING THE SAFE OR ARMED CONDITION PRIOR TO INSTALLATION INTO THE MUNITION. (b) A FEATURE WHICH PREVENTS INSTALLATION OF A FUZE INTO THE MUNITION IN ANY BUT THE SAFE CONDITION. (c) A FEATURE WHICH PREVENTS ASSEMBLING THE FUZE IN ANY CONDITION BUT THE SAFE CONDITION. THIS OPTION SHALL NOT BE USED ALONE IF ARMING THE FUZE DURING MANUFACTURE IS A NORMAL PROCEDURE.	REQUIREMENT IS SATISFIED. THE FUZE HAS A WINDOW THROUGH WHICH THE INTERRUPTER POSITION MAY BE VIEWED.
(4) ACCIDENTAL OR INADVERTENT ARMING - THE FUZE SHALL CONTAIN AN ARMING DEVICE WHICH CANNOT BE ACCIDENTALLY OR INADVERTENTLY ARMED DURING THE MANUFACTURE-TO-TARGET ENVIRONMENT.	REQUIREMENT IS SATISFIED. THE TERMINAL ENVIRONMENT SENSOR ENABLES THE ARMING OF THE FUZE ONLY IF AN IMPACT OF 190 FEET PER SECOND OR GREATER IS REALIZED IN THE PROPER TIME WINDOW.
(5) INTERRUPTER LOCK - THE FUZE SHALL CONTAIN AN INTERRUPTER THAT IS LOCKED UNTIL AFTER AIRCRAFT RELEASE. THIS INTERLOCK MUST BE CAPABLE OF WITHSTANDING THE ENERGY USED TO REMOVE THE INTERRUPTER.	REQUIREMENT IS SATISFIED. TWO INDEPENDENT LOCKS ARE EMPLOYED UNTIL AFTER AIRCRAFT RELEASE. THESE TWO LOCKS ARE MECHANICAL GAG AND SEAR.
(6) COMPONENT FAILURE - IF FUZE COMPONENTS (OR COMBINATIONS THEREOF) ARE USED THAT COULD CONCEIVABLY FAIL DURING THE MANUFACTURE-TO-TARGET ENVIRONMENT, THE FAILURE OF THAT COMPONENT (OR COMBINATIONS THEREOF) SHALL NOT CAUSE A HAZARDOUS CONDITION.	A HAZARDOUS CONDITION WILL OCCUR IF ANY ONE OF THE FOLLOWING OCCUR (1) THE FOLLOWING COMPONENT FAILURES OCCUR AT, BUT NOT PRIOR TO, IMPACT (a) PRINTED CIRCUIT BOARD PATH CONNECTING EC1 LEAD BREAKS. (b) Q13 SHORTS BASE COLLECTOR OR EMITTER COLLECTOR. (2) THE LEAD CUP INITIATES AT IMPACT OR SPONTANEOUSLY. (3) THE BOOSTER INITIATES AT IMPACT OR SPONTANEOUSLY. (4) THE CAPACITY OF E-CELL EC1 IS GREATER THAN 0.25 PERCENT OF NOMINAL AND LESS THAN 5.0 PERCENT OF NOMINAL. (5) THE BATTERY SELF-INITIATES, AND A 200 FPS IMPACT IS COMPLETED BEFORE ILAT TIMES-OUT.
(7) SAFE ESCAPE - THE FUZE SHALL CONTAIN AN ARMING DEVICE THAT WILL ALLOW FOR SAFE ESCAPE DISTANCE TO OCCUR BEFORE ARMING UNDER ANTICIPATED DELIVERY CONDITIONS.	REQUIREMENT IS SATISFIED. IN-LINE ARMING TIMER DELAYS MOVING EXPLOSIVE TRAIN INTERRUPTER (i.e., DETONATOR) IN LINE UNTIL AFTER IMPACT.
(8) ENVIRONMENT - (a) THE SAFETY FEATURES OF THE FUZE SHALL BE DESIGNED SUCH THAT THEY WILL NOT BE DEGRADED OR NEGATED THROUGHOUT THE MANUFACTURE-TO-TARGET ENVIRONMENT. (b) THE FUZE WILL BE DESIGNED TO PRESENT THE MINIMUM PRACTICAL HAZARD DURING UNNATURAL AND ACCIDENTAL ENVIRONMENTS INCLUDING ACCIDENTAL DROP, IMPROPER STORAGE, AIRCRAFT CRASH, FIRE, SYMPATHETIC DETONATION, AND COMBAT DAMAGE.	(a) AND (b) REQUIREMENT IS SATISFIED. MOVING EXPLOSIVE TRAIN INTERRUPTER (i.e., DETONATOR) IN LINE IS UNIQUE TO DELIVERY ENVIRONMENT. REFER TO THE HAZARD ANALYSIS FOR DETAILED INFORMATION.
(9) RENDER SAFE - THE FUZE DESIGN SHALL ALLOW FOR THE FUZE TO BE RENDERED SAFE (BY RENDER SAFE PROCEDURES) UNLESS SPECIFICALLY EXEMPTED FOR OPERATION REASONS.	REQUIREMENT IS SATISFIED. FUZE CONTAINS SPECIFIED EOD FEATURE.

TABLE III-1. FUZE SAFETY CRITERIA COMPLIANCE SUMMARY (CONCLUDED)

B. DESIGN OBJECTIVES	FMU-63/B FUZE
(1) STORED ENERGY - THE FUZE DESIGN WILL NOT INCORPORATE A STORED ENERGY MECHANISM WHICH IS USED TO REMOVE THE INTERRUPTER.	INTENT IS SATISFIED. ONLY AFTER THE SEAR LOCK IS REMOVED BY A UNIQUE ENVIRONMENT IS THE INTERRUPTER (i.e., DETONATOR) MOVED IN LINE WITH THE EXPLOSIVE TRAIN BY A PISTON ACTUATOR.
(2) DUAL INTERRUPTER LOCKS - THE FUZE DESIGN WILL INCORPORATE AT LEAST TWO INDEPENDENT LOCKS ON THE INTERRUPTER, EACH REQUIRING INDEPENDENT SOURCES OF ENERGY FOR REMOVAL. IF TWO INTERRUPTERS ARE USED, ONE INDEPENDENT LOCK ON EACH IS PERMISSIBLE.	OBJECTIVE IS SATISFIED. COMMON POWER SUPPLY REMOVES MECHANICAL GAG RETAINER AND MOVES INTERRUPTER SEAR. HOWEVER, THE TWO LOCKS ARE INDEPENDENT -- THE GAG IS MOVED BY IMPACT AND THE SEAR IS MOVED BY PISTON ACTUATOR.
(3) ENERGY AFTER LAUNCH - ONE OF THE LOCKS ABOVE WILL BE REMOVED BY ENERGY OBTAINED FROM AN ENVIRONMENTAL CONDITION AFTER LAUNCHING.	OBJECTIVE IS SATISFIED. MECHANICAL GAG IS REMOVED BY INERTIAL ENERGY FROM DELIVERY ENVIRONMENT.
(4) FIRING TRAIN INTERRUPTER - THE FUZE SHALL BE DESIGNED EMPLOYING AT LEAST ONE OF THE FOLLOWING OPTIONS: (a) TWO INDEPENDENT INTERRUPTERS SHALL BE USED. (b) OMISSION OF THE INTERRUPTERS SHALL PREVENT MUNITION FUNCTION. (c) THE FUZE CANNOT BE ASSEMBLED WITH THE INTERRUPTER OMITTED.	OBJECTIVE IS SATISFIED. OMISSION OF THE INTERRUPTER WILL PREVENT MUNITION FUNCTION SINCE THE DETONATOR WILL ALSO BE OMITTED.
(5) SAFE ARM INDICATION - THE FUZE SHALL CONTAIN A POSITIVE MEANS OF DETERMINING THE SAFE OR ARMED CONDITION AFTER INSTALLATION INTO THE MUNITION.	OBJECTIVE IS SATISFIED. DIAL SHUTTER INDICATES INTERNAL POWER ABSENCE OR PRESENCE. SAFING PIN INSTALLATION DETERMINES OUT-OF-LINE POSITION OF INTERRUPTER PRIOR TO BOMB NOSE ATTACHMENT.
(6) RETURN SAFE - THE FUZE SHALL CONTAIN A MECHANISM THAT WILL RETURN THE FUZE TO THE SAFE POSITION (OR DUD THE FUZE) IF THE ARMING SEQUENCE IS INITIATED AND THEN INTERRUPTED.	OBJECTIVE IS SATISFIED. IF THE ARMING SEQUENCE IS INITIATED AND SIGNALS ARE NOT PROPER WITHIN THE TIMING WINDOWS, THE FUZE WILL DUD.
(7) ELECTRIC INITIATORS - ELECTRIC INITIATORS SHALL NOT BE USED IN A FUZE WITHOUT EXPLOSIVE TRAIN INTERRUPTION.	OBJECTIVE IS SATISFIED. DETONATOR IS INTEGRATED WITH SLIDING INTERRUPTER WHICH MAINTAINS DETONATOR OUT-OF-LINE WITH FIRING PIN PISTON ACTUATOR AND EXPLOSIVE TRAIN.
(8) SEPARATION OF ARMING AND FIRING - THE ARMING AND FIRING FUNCTIONS OF THE FUZE SHALL BE INDEPENDENT. FAILURE OF ONE FUZE FUNCTION (ARMING OR FIRING) SHALL NOT ADVERSELY AFFECT THE SAFETY OF THE OTHER FUNCTION.	OBJECTIVE IS SATISFIED. ARMING AND FIRING FUNCTIONS OF THE FUZE ARE INDEPENDENT OF EACH OTHER AND CIRCUITS ARE ISOLATED.
(9) SELF-DESTRUCT/STERILIZATION - IF THE FUZE CONTAINS A SELF-DESTRUCT OR A SELF-STERILIZATION FEATURE, THE DESTRUCT/STERILIZATION TIME SHALL BE CONSIDERED CRITICAL. THE FUZE SHALL DESTRUCT/STERILIZE BEFORE THE TIME ESTABLISHED FOR DESTRUCT/STERILIZATION WITH A FAILURE RATE LESS THAN 1×10^{-6}.	THIS OBJECTIVE HAS BEEN ESTABLISHED AS A DESIGN GOAL FOR THE FUZE. FOR MORE INFORMATION, SEE SELF STERILIZATION ANALYSIS SECTION OF SAFETY ANALYSIS OF FMU-63/B LONG DELAY ELECTRONIC BOMB FUZE.

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13. ABSTRACT

for this fuze

The work described in this report was performed in compliance with Contract F08635-67-C-0051 and subsequent Modifications P001 through P00019. All phases of a complete development program were carried out with a goal of developing a safe and reliable long delay fuze that is compatible with available subsonic and supersonic delivery systems. The final result of this development program was a long delay (1.0 hour to 199 hour) bomb fuze compatible with retarded or non-retarded bomb systems in either nose or tail fuze well installations. Air Force test and evaluation of the final FMU-63/B fuzes revealed a functional reliability far below the desired value. The FMU-63/B fuze was not approved for pilot production and this development program was terminated. Final test results will be reported in a separate Armament Development and Test Center technical report.

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Anti-tamper						
Dial shutter						
Terminal Environment Sensor						